FOUNDRY TRADE JOURNAL

Established 1902

Vol. 93 Thursday, November 13, 1952 No. 1889

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PUBLISHED WEEKLY: Single Copy, 9d. By Post 11d. Annual Subscription, Home 40s., Abroad 45s. (Prepaid).

49 Wellington Street, London, W.C.2. 'Phone : Temple Bar 3951 (Private Branch Exchange) Grams : "Zacatecas, Rand, London"

Aluminium Foundry Technology

Last week and this, the Aluminium Development Association organized conferences in Birmingham and London with the object of stressing the importance of castings in the senior light alloy as engineering material. To support this, exhibitions of interesting and intricate sand- and die-castings were staged. A series of stimulating, but elementary technical and commercial papers by the staff of the Association and eminent specialists formed the background for discussion. As will be seen from the abstracts,* prominence was given to the insistence on accepting only castings conforming to a recognized standard specification, involving the exclusion of the use of "gypsied-up" scrap. The use of miscellaneous scrap is a major cause of defective material which may not be discovered until a breakdown occurs. Incidentally, the industry was promised—despite heavy exports to America—ample supplies of the virgin metal in the future.

The proceedings are to be assembled and made available to appropriate bodies in booklet form as soon as possible. From every angle—except one—the meetings were unquestionably a success. The discussions were of a high order, yet the interventions by the users were few and far between. What there was, however, was more than ordinarily interesting; for instance, one speaker pointed out that the great expansion in the export of motor vehicles had included sections of the world where corrosive waters were encountered. Naturally, he made a plea for greater attention to be paid to the production of alloys with enhanced corrosion resistance. A second speaker dealt with co-operation between the user and foundryman for the improvement in the design of castings, and pointed out that such collaboration was no guarantee that the order would not eventually be placed with a competitive firm. If this be the case, the sooner it is known that this sort of service is available from development associations or departments, the better.

A pretty problem was posed during the proceedings and that was as to whether it would be possible to communicate a really hard surface to an aluminium casting by a process analogous to case hardening. After all, corundum—an oxide of aluminium—is next to diamond in hardness! Unlike iron, steel, brass and bronze foundry practice, which developed in the workshop and later progressed with laboratory aid, aluminium was a laboratory discovery and workshop help had to be enlisted for its commercial exploitation. The conference showed that this need is still there and appropriately three papers were submitted detailing the actual production methods for difficult jobs. They help in a small measure to balance the volume of theoretical papers on the subject, which is so vast as to bewilder the practical man.

* Shortly to be printed.

Correspondence

[We accept no responsibility for the statements made or the opinions expressed by our correspondents.]

THE WHITE PAPER

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—I have read with interest the correspondence in the FOUNDRY TRADE JOURNAL on the new Iron and Steel Bill and am most concerned with the same statement which was made by both Mr. T. Lee and Mr. J. Bell in their letters published in last week's issue. Mr. Lee states: " . . . no new controls are being extended whatever." Mr. Bell states: " . . . it is not proposed to give the Iron and Steel Board any important powers not already vested in the Ministry of Supply."

The implication of both these statements is not correct. The written word in the Bill which has now been published gives far more power to the proposed Board than that which was vested in the Ministry of Supply. The present powers only control development and production capacity in foundries in so far as building-work expense is involved. That is to say, any foundry can now install without authorization new mechanical equipment to any extent providing a building licence of any description is not required from the Ministry of Works and Buildings. Under the new proposals (page 5, clause 5(*1*)) " any person proposing to provide or procure the provision of any additional production facilities in Great Britain shall give particulars in writing of the proposal to the Board and shall not proceed therewith without the consent in writing of the Board." This clause obviously adds all plant and equipment extension schemes to the Board's powers.

We have already been told that this is not the intention of the Bill, but argue as they will, it is obvious that it is to the written word we must look and not to the intentions of a Minister, or any Board representative, neither of whom will be there for ever.

Again, on page 10, clause 11(*1*), the Board are to be given powers to levy funds from the industry to meet the expenses of the Board. Is this one of the present powers vested in the Ministry of Supply ?

Again, on page 11, clause 13(*1*)(*a*), ironfounders will be obliged to produce " such books of account, records and documents, to supply copies of, or extracts from such books, records and documents and to furnish such other information, as may be reasonably required by the Board. Have the Ministry of Supply such wide snooping powers at present ?

Page 12, clause 14 (*4*) states " the Board shall compile and publish, or secure the compilation and publication of, such periodical statistics and reports relating to iron and steel products as may appear to them to be expedient." Doesn't this mean unlimited form filling and endless red tape ?

Again, the various clauses relating to research, training and education, safety, health and welfare, etc., give to the proposed Board unlimited powers which are not vested in the Ministry of Supply.

Finally, all these proposed new powers will be a permanent feature of the Statute Book and (page 12, clause 13(*2*)) states " If any person fails to comply . . . he shall be liable on summary conviction to imprisonment . . . "

To argue that none of this is the intention of the Bill is futile. If this was so why include ironfoundries in the Bill at all ? If it isn't the intention now it obviously will be at some future time and those people responsible for looking after our industry's interests should have fought these proposals tooth and nail instead of giving their support and co-operation to whoever was originally responsible for suggesting imposing these shackles on us.

In your leading article of July 31 you said " We ask all ironfoundry owners carefully to examine this White Paper, visualize its major implications and do all that is within their power through their own organizations to contract out of the proposed arrangements." Unfortunately the industry has been most tardy in accepting this good advice and there is now very little time left to give effect to it.

Those of us who are putting much effort into the campaign opposing these proposals do not accept the logic of the reassuring, appeasing and reiterated statement that " no new controls are being extended whatever."—Yours, etc.,

R. C. SHEPHERD,
Ruston & Hornsby, Limited.

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—We have been interested to read Mr. Kain's letter in your issue of October 30.

Admittedly, iron foundries consume pig-iron and scrap. They also consume foundry coke, electricity, gas, and coal. If it is necessary that iron foundries should come under the supervision of the proposed Iron and Steel Board, by the same reasoning they should be subject to the Coke Directorate, and Electricity, Gas and Coal Boards.

It is suggested that unless iron castings come under the Iron and Steel Board they cannot expect a fair share of raw materials. Why was not the same suggestion made in relation to coke, electricity, gas and coal?

As iron founders, what we ask for is elementary justice. We ask for the same treatment as given to drop forgings, steel pressings, steel stampings, steel fabrications, and alloy castings. These latter do not come under the supervision of the proposed Iron and Steel Board, neither should iron castings.—Yours, etc.,

T. WHITHAM,
Managing Director.
Blakey's Boot Protectors, Limited.

To the Editor of the FOUNDRY TRADE JOURNAL

SIR,—I apologize for the irritation I have caused Mr. Lee, but welcome the opportunity to repeat my complaint of the secrecy surrounding the negotiations. Can Mr. Lee produce the minutes of any meeting of any consituent association held prior to the publication of the White Paper when the intentions of the executive were explained to the members and a free vote taken?—Yours, etc.,

C. H. KAIN,
Joint Managing Director.
Lake & Elliot, Limited.

Dinner

BRITISH BRONZE AND BRASS INGOT MANUFACTURERS' ASSOCIATION

The first dinner/dance to be organized by the British Bronze and Brass Ingot Manufacturers' Association was held last Saturday evening at Grosvenor House, Park Lane. Mr. G. W. Booth presided and amongst the guests, most of whom were accompanied by their ladies, were Dr. W. E. Berry; Mr. G. B. Garnham; Mr. W. R. Marsland; Dr. Smithells; Mr. G. L. Bailey; Mr. L. G. Beresford and Mr. V. C. Faulkner. The function was organized by Mr. S. W. Platt. During the evening, the company was entertained by Henderson and Henshall (ball-room dancers); Norman Major (magician); and the Harvards (acrobats).

Ferrous Rod for Welding Nodular-graphite Cast Iron*

By R. V. Riley, Ph.D., B.Sc., F.I.M. and J. Dodd, B.Sc., L.I.M.

Experimental welds were made by the oxyacetylene and electric-arc methods to determine the welding properties of nodular-graphite cast iron. Whilst nodular-graphite cast iron proved to be more easy to weld than ordinary grey iron, it did not in any way resemble steel, and precautions were necessary to minimize residual stresses; otherwise longitudinal and transverse cracks formed in and around the weld deposit. Electric-arc welding, either with plain carbon or alloy electrodes, caused the formation of hard carbide flash at the base-metal/weld-metal junction. This was due to the very intense local heating and the comparatively rapid chilling of the pool of metal formed by the electric arc. Gas welding with proprietary cast-iron welding rods, whilst giving freedom from hard unmachinable deposits, yielded a weld of low physical properties due to the presence of flake graphite. A new welding rod was then developed for gas welding which contained just sufficient residual nodularizing element to yield on remelting a nodular-graphite cast-iron weld deposit. The microstructure, physical and mechanical properties of the weld deposit were similar to the nodular-graphite cast iron of the base casting. The technique for welding nodular-graphite cast iron using the new rod also resulted in a sound and stress-free weld. Since the weld has a similar composition to the base metal, no trouble should be experienced with localized electrolytic corrosion of the iron in or around the weld.

A great deal of foundry literature of recent years has been devoted to the relatively new engineering material—nodular-graphite cast iron. This type of cast iron is characterized by the spheroidal or nodular form of the graphitic carbon. The strength and toughness of cast iron thereby is much greater than that of unmodified cast iron in which the graphitic carbon is usually found in the form of flakes. Successful methods for the welding of ordinary flake-graphite cast irons are known and have been practised for many years. Nearly all these fusion-welding methods, however, entail the careful control of residual stresses in the weld area. This control is necessary because flake-graphite cast iron possesses little malleability and so does not allow relief of the residual stresses by plastic deformation, as occurs in the welding of steel. Cracks form as soon as the residual stress exceeds the yield stress of cast iron. Since all forms of nodular-graphite cast iron can withstand some plastic deformation and the annealed ferritic variety can actually twist and bend under stress in a manner similar to cast steel, it appeared possible that nodular-graphite cast iron yields more reliable welds than ordinary flake-graphite cast iron. Furthermore, the low sulphur and phosphorus contents of nodular-graphite cast iron would also facilitate welding. For these reasons the investigation described in this contribution was embarked upon.

An over-riding consideration during the whole investigation was that a successful technique for the welding of nodular-graphite cast iron should not use materials which were expensive or in short supply. It was hoped that it would be possible to weld nodular-graphite cast iron without elaborate heat-treatment prior to, or after, welding, and that welds should be made in all positions.

* A communication from the Research Department of the Staveley Iron and Chemical Company, Limited.

Electric-arc Welding

The first part of the work described relates to attempts made to establish a procedure for the electric-arc welding of nodular-graphite cast iron. Three types of coated electrodes were used to assess the ease with which nodular-graphite cast iron could be welded by the electric-arc welding method:—(1) Mild-steel electrodes of the type commonly used in welding fabrication for mild steel; (2) alloy electrodes containing about 60 per cent. nickel; and (3) proprietary welding rods obtained from two manufacturers and sold as suitable for the welding of cast iron. In every experiment, the recommended welding practice as stated by the electrode makers was adopted, and this included both the use of alternating current and direct current welding methods.

Test welds were laid down on nodular-graphite cast-iron specimens as described in Table I, scarfed and prepared for welding in the manner recommended for cast iron. For horizontal welds in the "down-hand" position, two flat plates, 8 by 5 by $\frac{1}{2}$ in., were welded together. Another type of weld specimen consisted of lengths of 4-in. i.d. nodular-graphite cast-iron pipe with a wall thickness of $\frac{1}{4}$ in. This type of weld test-specimen was chosen since it was felt that a constrained ring would demonstrate clearly the influence of residual stresses in the weld zone. Welding experiments were made with both magnesium- and cerium-treated nodular-graphite cast-iron specimens, both in the pearlitic as-cast form and in the ferritic, fully-annealed condition. Full details of the cast-iron welding specimens used in these experiments are given in Table I.

Preliminary Results.

By electric-arc welding methods, it was impossible to weld successfully any type of nodular-graphite cast iron without preheating the weld

TABLE I.—*Microstructure and Composition of Nodular-graphite Cast Iron Specimens Used in Welding Experiments.*

Type of specimen.	Composition (per cent.)					Microstructure.
	T.C.	Si	Mn	S	P	
Plates.						
Treated with ferro-silicon-magnesium	3.02	3.27	0.71	0.014	0.060	Graphite nodules and flakes in a pearlitic matrix.
" " "	3.10	3.63	0.65	0.020	0.100	Ditto.
Treated with ferro-silicon-magnesium and annealed ..	3.10	3.47	1.05	0.014	0.080	Nodular graphite in a ferritic matrix.
Treated with nickel-magnesium alloy	3.28	2.89	0.60	0.009	0.070	Nodular graphite in a mixed pearlitic and ferritic matrix.
Treated with nickel-magnesium alloy and annealed ..	3.22	2.82	0.56	0.009	0.070	Nodular graphite in a ferritic matrix.
Treated with cerium	3.64	3.13	1.45	0.015	0.070	Nodular graphite in pearlitic matrix.
" "	3.12	2.31	0.04	0.019	0.050	Nodular graphite in a mixed ferrite and pearlite matrix.
Un-treated grey iron	2.72	2.53	0.04	0.018	0.030	Flake graphite in a pearlitic matrix.
Pipe.						
Treated with cerium	3.19	3.99	0.99	0.010	0.045	Nodular graphite in a mixed ferrite and pearlite matrix.

test-pieces to at least 300 deg. C. All attempts to lay down a weld deposit on cold test-pieces resulted in longitudinal and transverse cracks which developed in the weld deposit. The usual technique adopted to minimize the formation of dangerous stresses in the weld zone, such as block, step, sequence welding, and the use of a very low welding current, proved unsuccessful. Weld deposits could be made without the formation of cracks if a minimum preheating temperature of about 300 deg. C. were adopted. The nickel-alloy electrodes were the least susceptible to crack formation whilst the mild-steel electrodes were the poorest in this respect, cracking occurring in both the weld deposit and the adjacent metal.

Structure of the Deposit.

The weld deposit laid down with the mild-steel electrodes showed a silky fracture, tending in places to contain areas of mottled iron. In these mottled zones, the weld deposit was hard and unmachinable and the zone adjacent to the weld invariably contained massive carbides, martensite and other transformation products. A large number of gas holes were noted in welds made with the mild-steel electrode. The nickel alloy electrode gave a soft weld-deposit which was easily machinable, but once again the area adjacent to the weld was marked by a zone containing carbides and hard transformation products. Very poor penetration occurred and the welds were lacking in ductility and strength.

The proprietary types of electrodes used for the welding of cast iron gave in most cases deposits which contained carbides and the welds were relatively weak. Once more a hard zone developed adjacent to the weld.

Electric-arc Welding with High Preheating Temperatures.

A series of welds were laid down using a preheating temperature of 600 deg. C. Even at this temperature, the formation of cementite at the weld junction was not entirely prevented, although the hardness of this zone was decreased considerably. Welds made with a high preheating temperature were characterized by porous weld-deposits. With all the welding electrodes tested, gas appeared to be generated at the nodular-graphite cast-iron junction with the weld metal and the resultant deposits were of low strength. In view of the difficulties experienced with the electric welding of nodular-graphite cast iron, the technique was abandoned and experiments were continued with gas welding.

Gas Welding

The same type of nodular-graphite cast-iron specimens as previously described were used for new experiments with gas welding. Two types of filler rods were tested in conjunction with a proprietary cast-iron welding flux supplied by the same makers:—(1) A high-silicon cast-iron welding rod supplied for the welding of ordinary flake-graphite cast irons; and (2) a cast-iron welding rod containing nickel. Successful welds were laid down on the sample plate-welding specimens without prior preheating. With the pipe specimens in general it was found necessary to preheat to prevent the formation of cracks.

Examination of the Weld Deposits.

The weld deposits were free from cementite. Some hardening occurred at the junction of the weld deposit with the nodular-graphite cast-iron plate but the whole area was quite easily machinable. The weld deposits contained fairly fine flake-graphite in a matrix of pearlite. Physical tests on the welded specimens showed that the weld deposits lacked ductility and the tensile tests on test-bars machined from the plate specimens proved that the weld metal was much weaker than the nodular-graphite cast-iron base castings. No difficulty was experienced, however, in laying down sound weld deposits and in this respect nodular iron appeared to be much easier to weld than ordinary flake-graphite cast iron.

Limitations

It was clear at this stage in the investigation that all the available commercial methods of welding nodular-graphite cast iron had serious limitations. A discussion of the results indicated:—

(1) Nodular-graphite cast iron of the type used in the welding tests was easier to weld than ordinary commercial grey iron by both the electric-arc method and the oxyacetylene gas method. The comparative ease with which nodular-graphite

cast iron could be welded appeared to be due to the low level of sulphur and phosphorus in this iron. Test plates of a flake-graphite cast iron containing only the same level of sulphur and phosphorus, were found to be weldable with the same ease as a nodular-graphite cast iron.

(2) Residual stresses occurring during welding were not accommodated completely by the nodular-graphite cast iron, and arc weld deposits on a fully-annealed ferritic iron contained longitudinal and transverse cracks. This trouble was overcome to some extent by preheating prior to welding.

(3) None of the electric-arc weld deposits was free from iron carbide and hard transformation products at the weld-metal junction. This hard zone greatly reduced the ductility and strength of the weld. The very high localized heat and rapid cooling rate of the weld deposit inherent in the electric-arc welding process could not fail to produce such a weld junction in a high-carbon material like nodular-graphite cast iron. The use of methods employing low amperage and short runs, whilst decreasing the residual stresses in the weld, also served to increase the amount of carbide found in the weld junction. These methods were also painfully slow and therefore cannot be considered practicable for large welds.

(4) In the process of gas welding, more heat was available at the weld junction and little difficulty was experienced in producing gas weld deposits fairly free from carbides and hard transformation products. The lower rate of cooling of the gas-welded deposit also allowed more time for slag and gases formed during welding to float out of the molten metal pool. In consequence, these deposits were much more free from gas holes and slag inclusions than were the electric-arc welded deposits.

(5) Oxyacetylene gas welds were found to give fairly low physical test results. This was due to the formation in the weld of flake-type graphite. The welding rods used were of a fairly high silicon content, so that even under ideal welding conditions, the highest strength obtainable in the weld deposit would necessarily be considerably less than a common high-duty flake-graphite cast iron containing a much lower silicon content. Thus, a weld deposit could not be expected to approach the strength of a nodular-graphite cast iron. Nickel-cast-iron welding rods also gave deposits much weaker than nodular-graphite cast iron.

(6) Braze-welding was not attempted, since it was felt that the high cost of the filler rod would limit the application of the method. Furthermore, welded castings subjected to corrosive conditions should have welds of a similar composition to the base metal in order to avoid electrolytic attack of the iron. In this respect, braze-welding of cast iron renders it more susceptible to corrosive attack. Properly carried out by an experienced operator, however, the braze-welding method should give weld junctions of satisfactory strength.

On the basis of the experimental work described, it was decided that, (*a*) a ferrous welding rod capable of making weld deposits of greater strength and ductility than those available at present was required, and (*b*) the oxyacetylene gas-welding process appeared most likely to give success in the welding of nodular-graphite cast iron.

Rod to Deposit Nodular-graphite Cast Iron

Since the low strength and ductility of the weld-metal deposit from a high-silicon cast-iron welding rod is due partly to the presence in the weld of graphite in the flake form, it was realized that if the graphite could be nodularized, much better physical properties of the weld metal could be expected. The modifying elements, magnesium and cerium, have a high affinity for oxygen, and it is usually accepted that, on remelting a nodular-graphite cast iron, these elements are lost by oxidation and possibly also by combination with sulphur in the melting furnace. However, all chemical reactions require a finite time for completion and it was postulated that the removal of cerium or magnesium to an ineffective level for nodularizing purposes might take an appreciable time. A series of experiments was carried out to determine the rate at which the modifying elements were oxidized. These experiments showed conclusively that providing the nodular-graphite cast iron was melted rapidly, sufficient of the modifying element could be retained to re-nodularize the graphite in the iron on second casting. Fig. 1 shows the rate of oxidation of magnesium from iron kept molten at 1,400 deg. C. in a 10-lb. capacity induction furnace open to the atmosphere. The results of this experiment indicated clearly the possibility of carrying out a welding operation before the modified element magnesium was removed entirely. Exactly similar considerations were shown to apply with cerium.

Unfortunately, the commonly-used modifying elements, cerium and magnesium, are both carbide stabilizers, and an excess can cause the formation of massive carbides. To regulate the nodularizing agent in a welding rod so as to permit of the nodularizing

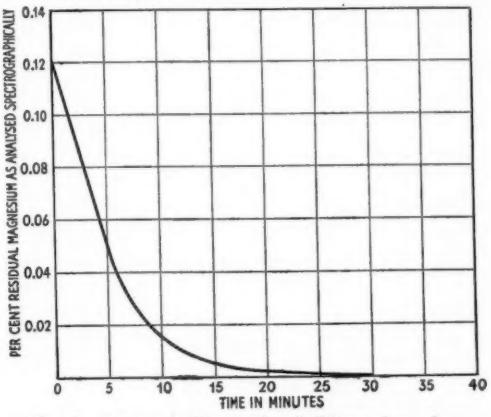

FIG. 1.—*Rate of Removal of Magnesium from Molten Cast Iron at* 1,400 *deg. C. under Experimental Conditions.*

of graphite in the weld deposit and at the same time to maintain a soft, machinable weld, called for careful observation and the development of a standard method of welding. A series of alloys containing increasing percentages of the modifying elements was prepared. Welding rods cast from these alloys were used to lay down weld-deposits which were

TABLE II.—*Physical and Mechanical Properties of Gas-welded Cast Iron Using Staveley Nodular-graphite Cast-iron Welding Rods.*

Welding details.	Quality of weld.	Average tensile strength in tons per sq. in.	Microstructure.
Plates.			
Magnesium-treated plates of nodular-graphite iron, gas welded, standard technique	Completely sound and well-fused root	25	Ferrite and nodular graphite.
Untreated flake-graphite iron, gas welded, standard technique	Completely sound and well-fused root	8	Nodular-graphite weld and flake-graphite base iron.
Cerium-treated plates of nodular-graphite iron, gas welded, standard technique	Completely sound and well-fused root	22*	Ferritic nodular-graphite in weld
Test-piece cut from original plate, *not* welded	—	22	Mixed ferrite/pearlite nodular-graphite iron.
Pipes.			
Cerium-treated nodular-graphite iron pipe, gas welded, standard technique	Good weld but rather shallow	21	Mixed ferrite/pearlite, with nodular-graphite iron.

* Weld specimens tested broke in tensile in an area well outside the heat-affected zone, with the exception of this specimen.

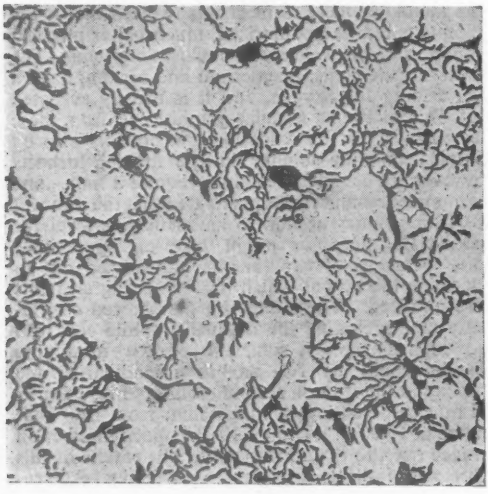

FIG. 2.—*Cerium added,* 0.06 *per cent.*

subsequently sectioned and examined metallographically. Alloys containing insufficient cerium or magnesium gave weld deposits which contained flake graphite (see Fig. 2). The transition from flake graphite to nodular graphite in the weld deposit was quite regular and depended upon an increase in the amount of modifying element in the initial alloy. Figs. 2, 3, and 4 illustrate the cerium series and from

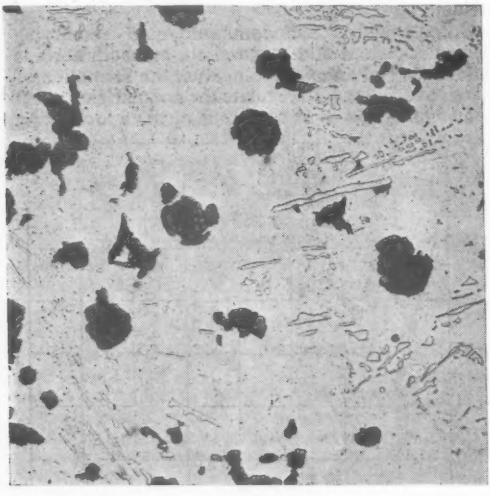

FIG. 3.—*Cerium added,* 0.185 *per cent.*

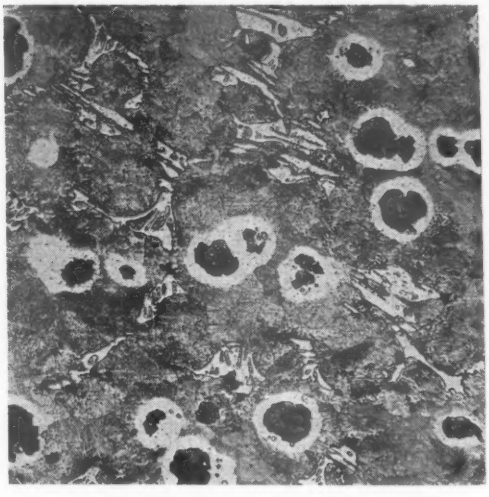

FIG. 4.—*Cerium added,* 0.25 *per cent.*

FIGS. 2 TO 4.—*Influence upon Microstructure of the Weld-deposit of Cerium added to a Welding Rod, all* × 250 *dia. Original Composition of Welding Rods* :—*T. C,* 3.4; *Si,* 2.5; *Mn,* 0.01; *S,* 0.01, *and P,* 0.04 *per cent.*

these experiments the minimum percentage of cerium required to form nodular graphite upon remelting was established. Magnesium and cerium were used both separately and together and both elements were found to behave in a similar manner in respect of the critical percentage of modifying element. It proved possible, therefore, to develop the welding rod by additions of either cerium or magnesium, or both elements together. Having determined the required percentage of modifying agent, welding rods were cast of suitable composition to lay down a nodular-graphite cast-iron weld deposit. To illustrate the results obtained when welding with a nodular-graphite cast-iron welding rod, a cerium-treated iron rod is taken as an example. It should be understood, of course, that similar results were obtained also with magnesium-treated cast-iron welding rods.

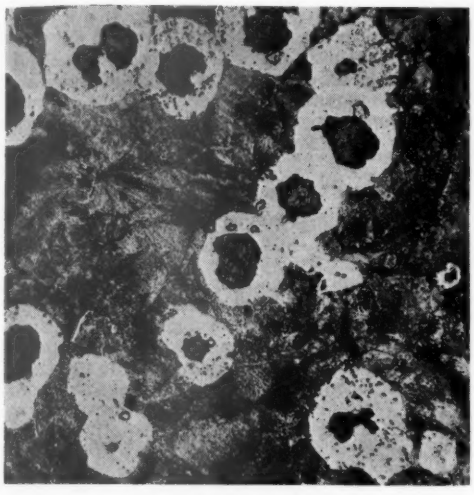

FIG. 5.—*Base Metal of Nodular-graphite Iron.*

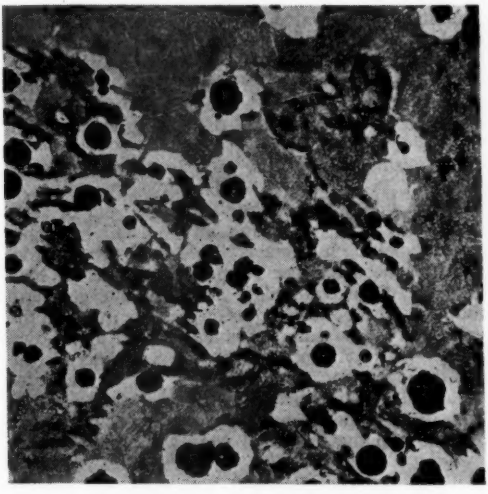

FIG. 7.—*Junction Typical Weld/Base Metal.*

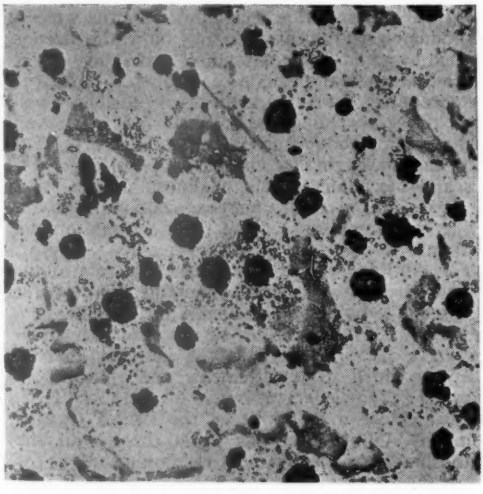

FIG. 6.—*Weld Deposit in Nodular-graphite Iron.*

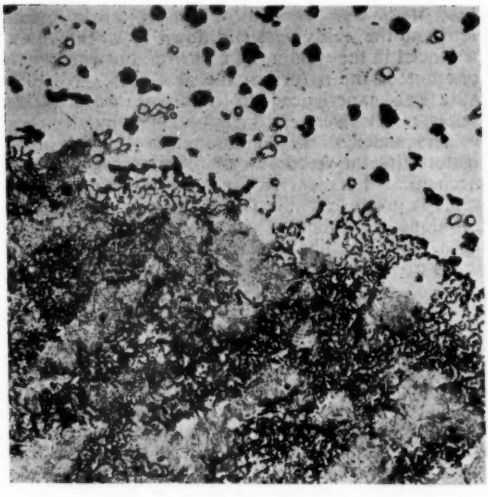

FIG. 8.—*Junction N.-g. Weld/F.-g. Base Metal.*

FIGS. 5 TO 8.—*Microstructure of Welds made with Nodular-graphite Cast-iron Welding Rods under Works Conditions (all* × 250 *dia.). Average Composition of Welding Rods:—T.C.* 3.4; *Si,* 3.0; *Mn,* 0.01; *S,* 0.01; *and P,* 0.04 *per cent. Average Composition of Base Iron:—T.C.* 3.5; *Si,* 2.5; *Mn,* 0.30; *S,* 0.01, *and P,* 0.10 *per cent.*

Ferrous Rod for Welding Nodular-graphite Cast Iron

Nodular-graphite Cast-iron Welding Rods.—The base iron from which the experimental cerium-treated welding rods were prepared was not critical, provided the now well-understood general rules relating to the nodularizing treatment of cast iron were obeyed. For experimental purposes, for the manufacture of the cerium-treated cast-iron rod, it was convenient to use Swedish pig-iron which effectively combined the desirable features of high-carbon, low-sulphur, low-phosphorus and low-manganese contents. This iron was remelted with additions of steel and ferro-silicon to give a welding-rod percentage composition of:—Total carbon, 3.4; silicon, 3.5; manganese, 0.02; sulphur, 0.01; phosphorus, 0.03; and cerium added, 0.2.

The welding rods were cast in sand moulds to give rods 18 in. long by $\frac{5}{16}$ in. square section. As cast, the rods were of white iron, but were of sufficient strength to withstand any normal handling. Upon remelting in the acetylene torch, the weld deposit produced had the desirable properties of high strength and machinability and was quite grey and nodular. Photomicrographs of the base iron and the weld in a successful experimental weld are shown in Figs. 6 and 7. In this case, the weld was ferritic and the base iron was pearlitic. Fig. 8 illustrates the actual junction between the base metal and the weld in an experiment where the base metal was pearlitic and the deposited weld was also pearlitic.

Experiments with New Rods

A number of welding trials were made using welding rods of the new type described. Some of these trials were carried out under works conditions and the welds were laid down by workmen experienced in the welding of cast iron, but completely ignorant of the nature of the new rods. No difficulty was experienced in obtaining good welds. Better results were, in fact, obtained by the shop welders under works conditions than by the investigators in the laboratory. A summary of the mechanical tests carried out on the experimental welds is given in Table II. With a proper welding technique, no difficulty was experienced in producing a grey, machinable weld having a strength upwards of 25 tons per sq. in.

Applications for Nodular-graphite Rods

It was clear from the experimental work already described that the welding rod could be used successfully with any form of nodular-graphite cast-iron plate or pipe specimens. It was a matter of some interest to discover that a nodular-graphite cast-iron weld could also be laid down on ordinary cast-iron plates having a flake-graphite structure. Fig. 8 shows the junction between the weld deposit and the original casting in which the weld deposit was a ferritic nodular iron and the base iron a pearlitic flake-graphite iron. The junction had a perfect fusion zone, but the structure changed sharply from flake to nodular graphite. It should be observed that in this case the base iron was low in sulphur and phosphorus and was an iron which would have been amenable to modification by cerium or magnesium. Base irons of high-sulphur content or those containing elements seriously harmful to the nodularizing additions failed to give a completely nodular-graphite weld-deposit. There were, however, a number of borderline compositions and these irons would in varying degrees be suitable for welding with nodular-graphite cast-iron rods to give a strong nodular-graphite cast-iron weld deposit. The new welding rod has, therefore, a wider application and might be used advantageously for ordinary grey iron welding where the benefits of a strong, sound and non-cracking weld are required. A range of rods of different chemical compositions could be developed to suit different grades of cast iron.

Important Note on Welding Technique

In welding nodular-graphite cast iron, just as with other types of cast iron, it was found to be important to build up the weld to the full thickness at one pass. Welding should begin with a shallow root weld, followed at once by the main deposit. A high rate of heat input should be applied and a large pool of weld deposit maintained. This proviso limits the welding technique in respect of overhead welding. The deposition subsequently of a thin surface layer of weld metal to complete the weld was found bad practice, as the newly deposited layer always contained carbides. When this precaution was recognized, any average welder had complete success with the welding rods described.

Conclusions and Acknowledgments

(1) The investigation has shown that the welding of nodular-graphite cast iron may be readily accomplished by adopting a gas-welding technique.

(2) The nodular-graphite cast-iron rod developed in the course of this work makes it possible to employ the gas-welding method for the fabrication and repair of nodular-graphite cast-iron parts. The weld deposit, having a composition, physical properties and mechanical strength almost identical with the base iron, gives a homogeneous composite differing in no important detail from a single or unit casting.

The Authors wish to thank the directors of the Staveley Iron and Chemical Company, Limited, for permission to publish the results of this investigation, and Dr. J. E. Hurst, director of research, with whom they have discussed details of the work and thereby received much encouragement and inspiration. Grateful acknowledgment is also made to Mr. L. C. Percival, chief metallurgist of the British Oxygen Company, Limited, for his initial help with the establishment of a satisfactory welding technique for cast iron.

Latest Foundry Statistics.—According to the British Bureau of Non-Ferrous Metal Statistics, the output of copper-base castings during the first nine months of this year was 50,990 tons as compared with 47,283 tons for the corresponding period of last year.

Institute Elects New Members

At a meeting of the Council of the Institute of British Foundrymen, held at the Midland Hotel, Manchester, on October 18, the following were admitted to the various grades of membership.

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As Subscribing-firm Member

Seymours' Castwell Foundry, Limited, Litchurch Lane, Derby, brass and aluminium founders, wood and metal patternmakers. (Representative: Mr. R. F. Seymour.)

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As Associate Member

N. Sanders, works manager, North Eastern Iron Refining Company, Stockton.

As Associates (over 21)

G. J. Hickling, castings inspector, Ashmore Benson Pease & Company, Limited, Stockton; G. K. Suggitt, patternmaker, Head Wrightson & Company, Limited, Middlesbrough.

As Associate (under 21)

J. B. Hall, laboratory assistant, North Eastern Iron Refining Company.

* Transferred.

Iron & Steel Institute

The autumn general meeting of the Iron and Steel Institute will be held on November 26 and 27, at the offices of the Institute, 4, Grosvenor Gardens, London, S.W.1. The President, Captain H. Leighton Davies, C.B.E., will be in the chair. The programme includes papers on "Cooling of Rimming Steel Ingots in a Casting Pit," by R. T. Fowler and L. H. W. Savage; "Time Studies from Casting to Rolling," by A. V. Brancker, J. Stringer and L. H. W. Savage; "Mould and Ingot Surface Temperature Measurements," by A. V. Brancker; "Ingot Mould Temperature Measurements," by R. T. Fowler and J. Stringer; "Development of Active Mixer Practice at Appleby-Frodingham," by A. Jackson; "Thermodynamic Properties of Silicon Monoxide," by N. C. Tombs and A. J. E. Welch; "Phosphorus-oxygen Equilibrium in Liquid Iron," by J. B. Bookey, F. D. Richardson and A. J. E. Welch; "The Free Energies of Formation of Tricalcium and Tetracalcium Phosphates," by J. B. Bookey; "The Free Energy of Formation of Magnesium Phosphate," by J. B. Bookey; "Effect of Sodium Oxide Additions to Steelmaking Slags: II—Dephosphorization of Steel by Soda Slags," by W. R. Maddocks and E. T. Turkdogan; "Phase Equilibrium Investigation of the Na_2O-P_2O_5-SiO_2 Ternary System," by E. T. Turkdogan and W. R. Maddocks; "Thermodynamics of Substances of Interest in Iron and Steel Making: III—Sulphides," by F. D. Richardson and J. H. E. Jeffes; "A Stoichiometric Combustion Method for the Determination of Sulphur in Slags," by C. J. B. Fincham and F. D. Richardson; "The Thermodynamic Calculation of Slag Equilibria," by H. Flood and K. Grjotheim; "Addition of Boron to Steel by Reduction from Boron Oxide," by G. E. Speight; "Effect of Direction of Rolling and Straining and of Ageing on the Mechanical Properties of a Mild-steel Plate," by C. F. Tipper; and "Rapid Softening of Cold-drawn Austenitic Stainless Steels," by F. A. Hodierne and C. E. Homer.

Influence of Different Clay Bonds on the Properties of Moulding Sands

Mr. O. Carlsson and Mr. S. Rydén have abstracted the article under the above title which appears in the Swedish journal, *Gjuteriet*, in the following statement:—

The influence of different clay bonds on the properties of moulding sands has been investigated, and natural sodium bentonite, synthetic sodium bentonite, natural calcium bentonite, soda-treated calcium bentonite and kaolinite clay have been tested. American natural sodium bentonite and North African calcium bentonite gave almost the same green-strength. Sodium bentonite gives higher dry-strength and also higher hot-strength than calcium bentonite and kaolinite clay. A moulding sand bonded with kaolinite clay does not dry on the surface as soon as a sand bonded with bentonite. Calcium bentonite gives less drying tendency than sodium bentonite. Scabbing has been studied on test castings. The sands bonded with sodium bentonite had the least tendency to scabbing and kaolinite clay had the greatest. Sands bonded with sodium bentonite had the longest life. In most cases, natural sodium bentonite turned out to be better than synthetic sodium bentonite. Soda-treated calcium bentonite had in several respects properties indicating that some calcium ions had been replaced by sodium ions.

Research on Atmospheric Dust in Steel Foundries with Special Reference to the Use of Statistical Surveys*

By G. M. Michie, M.A., A.Inst.P., A.I.M. and G. H. Jowett, B.A., F.S.S.

(*Continued from page* 535)

V—STATISTICAL CONSIDERATIONS

(*a*) *Concept of Mean Dust Level.*—The mean dust level at any given instant in any one foundry area can strictly speaking only be determined by the idealistic procedure of taking the average value of results of a very large number of " snap " samples collected simultaneously at points evenly dispersed throughout the area in question. The larger the number of samples, the more nearly may the calculated average be expected to approach the true mean dust level at the particular instant chosen. Similarly the true mean dust level for any particular location and for any particular day can only be assessed by averaging a very large number of these instantaneous averages obtained at close and equal intervals throughout the day. This averaging may be extended to obtain weekly mean dust levels for particular areas (area/week/means), daily mean dust levels for all foundries, or in fact mean dust levels over any combination of variables which may be of interest.

(*b*) *Parallelism in Statistical Comparisons.*—In practice it is impossible to sample on the scale suggested above, and the mean dust levels must be estimated from means of aggregates of samples obtained at points fairly widely separated in space and time. In consequence it is necessary to plan the choice of these aggregates in such a way as to avoid bias in comparisons of estimates of mean dust levels based on them.

If the means of two heterogeneous groups of readings are to be compared, both groups should be parallel in the sense that each reading taken on one day should have a parallel on the other (*e.g.*, taken on the same day in the same area and at the same time). This requirement may be relaxed in ways exemplified by either of the following:—

(*a*) If time effects may be assumed constant from area to area, for the purposes of a comparison between Monday and Tuesday, a fettling area 9.30 reading and a shot blast area 11.30 reading on a Monday may be regarded as effectively parallel to a fettling area 11.30 reading and a shot blast 9.30 reading on a Tuesday. Although the parallel is not exact, the additive nature of the effects makes the comparison of such pairs of readings a balanced one. A pair of Monday readings as described above could not, however, be regarded as effectively parallel to a fettling 3.30 reading and a shot blast 11.30 reading. A comparison between the means of such pairs of readings might suggest that Monday readings were dustier than Tuesday readings when in fact the excess mean dustiness of Monday was actually due to the tendency for 9.30 readings to be dusty. In statistical terms, such a comparison would be biased. This effective parallelism is a notable feature in such experimental designs as the " Latin Square." The design of the survey in Section IVA takes advantage of it to a limited extent.

(*b*) Parallel and strictly balanced designs can be complicated both to carry out and to analyse if too many different factors are brought in explicitly. It is sometimes possible to reduce the number by using a procedure of random selection. If the times of day upon which Monday observations are taken are selected at random, they will be representative " on the average " of Monday readings, because each time of the day will tend to turn up equally often. Thus a period which may be usually, say, rather bad will not run the risk of being systematically omitted. Two such random samples taken respectively on Monday and Tuesday, though not yielding such precise estimates as two strictly balanced samples of equal size, would be " parallel on the average." Use of such samples would avoid both the difficulty of choosing beforehand a small representative set of times of day at which to take systematic readings and the potential bias in such a choice. Further, it would make it unnecessary to take explicit account of time of day as a factor in analysis. Unfortunately, such random samples are not always easy to administer; it is not sufficient to take readings haphazardly; they must be taken at times drawn by lot beforehand.

Parallelism, both exact and modified in these ways, is the basic feature of the so-called " factorial experiment " with its desirable statistical characteristics. Further reference may be made to R. A. Fisher.[11] Failure to secure parallelism may result in biased comparisons such as that described in IV A (*d*).

TABLE VII.—*Analysis of Variance: Modified Weekly Average Group Numbers for Foundries, Areas and Weeks.*

Source of variation.	Sum of squares.	Degrees of freedom.	Mean square.
Between foundries (F) ..	1,008.84	5	201.77
Between areas (A) ..	268·78	4	67·45
Between weeks (W) ..	760.0	13	58·46
Interactions:			
A × W	216.22	52	4.16
W × F	1,212.50	65	18.65
F × A	457.70	20	22.89
Error interaction FAW ..	1,050.04	260	4.04
Total	4,974.08	419	11.87

NOTE.—Unit = ¼ group number.

* Paper presented to the Buxton Conference of the Institute of British Foundrymen.

TABLE VIII.—*Analysis of Variance: Day of Week Effects for Foundries, Areas and Days of Week.*

Source of variation.	Sum of squares.	Degrees of freedom.	Mean square.
Between days of week (D)	46.39	4	11.60
Interactions:			
D × F	59.35	20	2.97
D × A	11.39	16	0.71
Error interaction:			
D × F × A	112.89	80	1.41

NOTE.—Unit = ½ group number.

(c) *Statistical Error and Significance Tests.*—In assessing the results of dust readings taken by actual observers, two problems of inference arise, both of which require the use of statistical techniques. The first is a problem concerned with accuracy of description. It is necessary, for example, to use a measure of statistical error to determine how accurately an observed area/day/week mean (*e.g.*, the average of all readings actually taken in a shot blast area on a particular Monday) estimates the true area/day/week mean. The second problem, on the other hand, is one of prediction. For example, if for a particular set of weeks the mean dust level on Mondays has been approximately a certain amount higher than the mean dust level on Tuesdays, it is necessary to use statistical tests to determine how far such a difference could be fortuitous, and how far it establishes a fundamental underlying difference in level between the two days, warranting further investigation.

It is highly desirable that a survey should be designed in such a way as to furnish sufficient information to enable such measures of error to be determined and tests of significance to be carried out. It is beyond the scope of this paper to go more deeply into these questions, but it may be remarked that parallelism is an almost essential requirement in the design if it is to do this at all adequately. Further reference may be made to R. A. Fisher[11] where the application of Analysis of Variance to such problems as these is fully discussed.

(*d*) *Choice of a Scale of Measurement of Dust Level.*—It will be evident that the use of a comparator scale in which the dust concentrations between adjacent steps are arranged in geometrical progression, gives rise to a scale of "group numbers," equal increments in which do not correspond to equal increments in dust concentration as measured in particles per m.l. In the ordinary way the choice of scale would be immaterial, since the one is readily convertible to the other, but if statistical methods of analysis are to be applied, a choice must be made as to which scale of dust concentration is most suitable for use.

The statistical considerations affecting the choice between different measures of dust level are centred around the interpretation of the term "mean dust level." Whereas there is an exact correspondence between group number and number of particles per m.l., there is no such correspondence between "mean group number" and "mean number of particles per m.l." There is no obvious reason why the mean number of particles per m.l. should be uniquely relevant, from the point of view of health hazard; "modal" number of particles per m.l. (*i.e.*, the concentration which occurs most frequently) might be considered equally relevant as a measure of dustiness. The two measures are not usually equal, mean number generally being much greater than modal number.

An estimate of dust level consisting of the average number of particles per m.l. in a number of counts is very susceptible to occasional high values. The mean group number is very much less influenced by occasional erratic observations of this kind, and it so happens that mean group number and modal group number are not usually very different.

On the basis of such considerations, analysis of counts expressed in group numbers, in which the dust concentration between adjacent steps are arranged in geometrical progression is probably the more satisfactory procedure for the establishment of dust levels.

TABLE IX.—*Analysis of Variance: Time of Day Effects for Foundries, Areas and Time of Day.*

Source of variation.	Sum of squares.	Degrees of freedom.	Mean square.
Between times of day (T)..	35.42	3	11.81
Interactions:			
T × F	65.16	15	4.34
T × A	12.41	12	1.03
Error interaction:			
T × F × A	70.07	60	1.17

NOTE.—Unit = ½ group number.

VI—ACKNOWLEDGMENTS

The Authors wish to acknowledge permission granted by the British Steel Founders' Association to publish the results of the two surveys summarized in section IV, which were carried out on the Association's behalf by the Research and Development Division.

APPENDIX A
Adjustments of Out-of-Place Readings

If a reading has been omitted, a dummy reading may be supplied by means of the following missing plot technique (see M. G. Kendall[12]), and the data then analysed in effectively the ordinary way. The analysis becomes approximate, but advantage can still be taken of a balanced design.

A simpler alternative procedure which may also be used for adjusting a reading taken at the wrong time, is illustrated in the example below. It is not quite so satisfactory on theoretical grounds but may be expected to work fairly well in practice. It was used extensively in analysing the survey of Section IV.

Neither method is very satisfactory if too many readings are omitted or out of place. Under these circumstances, statistical analysis becomes very troublesome.

Example

Readings were taken as indicated by the crosses in the pattern shown in Table X.

In this pattern the reading taken at 3 p.m. on Thursday in the third week should have been taken

TABLE X.—*Section of an Experiment with an Out-of-place Reading.*

Day.	First-week time, 9	11	1	3	5	Second-week time, 9	11	1	3	5	Third-week time, 9	11	1	3	5	Fourth-week time, 9	11	1	3	5
Monday	×	—	—	—	—	—	—	×	—	—	—	—	—	—	×	—	×	—	—	—
Tuesday	—	×	—	—	—	—	—	—	×	—	×	—	—	—	—	—	—	×	—	—
Wednesday	—	—	×	—	—	—	—	—	—	×	—	×	—	—	—	—	—	—	×	—
Thursday	—	—	—	×	—	×	—	—	—	—	—	—	—	×	—	—	—	—	—	×
Friday	—	—	—	—	×	—	×	—	—	—	—	—	—	×	—	×	—	—	—	—

NOTE.—This pattern is assumed to continue for a multiple of five weeks.

at 1 p.m. The following procedure could be used to adjust it:

Calculate the average Monday 1 p.m. reading minus the average Monday 3 p.m. reading, and so for the other days of the week. Average these differences, and add the result to the reading which was incorrectly taken.

If the reading had been omitted altogether, the following procedure could be used to supply a dummy reading:

Step 1.—Average the Monday figures for all weeks except the one with the missing reading and four others chosen at random, representing the times 9, 11, 1, 3. This average will give equal representation to all four times of day. Compute also averages with the same property for the other days of the week.

Step 2.—Calculate the average of the four averages corresponding to days other than Thursday. Calculate the excess of the Thursday average over this average. Following a similar procedure calculate a similar figure for the excess of the 1 p.m. average over the average of the four averages for the other times of day.

Step 3.—Calculate the average of the four available readings and add the two excesses calculated above. This is the dummy reading required.

Clearly, it is very advantageous not to miss observations in a design as complex as the one just described.

APPENDIX B

Analyses of Variance for the Survey of Section IV A

The average of the five observations taken in a particular area in a particular week represented one time of day twice. A correction was made (by a method very like that of Appendix A) to each weekly average to give the times of day equal representation. These modified weekly averages were analysed as in Table VII.

The three interaction mean squares may be divided by the error mean square, and compared with the 5 per cent. point of the appropriate variance ratio distribution (see Fisher and Yates[13]). This test shows that the interactions W × F and F × A are statistically significant. This implies that area-to-area differences and week-to-week differences are not the same in all foundries but differ from one to another. On the other hand, the differences between areas remain fairly constant from week to week. Owing to significance of both these interactions, there is no completely satisfactory error term with which to compare the other two. Their mean squares are, however, sufficiently greater than the interaction mean squares to make it worth while to give a crude overall picture of the main sources of variation in terms of overall foundry and area means, as has been done in Table IV and the corresponding diagrams. The between weeks mean square is of no particular interest.

The interaction mean square D × F was significant, the other not. This implies that day-to-day differences vary from foundry to foundry, but not from area to area. The size of the between days of week mean square compared with this interaction mean square suggested that Table V was justified as giving a crude picture of the situation.

The interaction mean square T × F was significant, the other not. This implies that true time of day differences vary from foundry to foundry, but not from area to area. The size of the between times of the day mean square compared with this interaction mean square justified the crude picture of the situation given in Fig. 6.

Since some of the means given in Table IV, V and VI were based on comparatively small numbers of observations, it was thought desirable to add a footnote indicating their possible statistical error. This figure is twice their standard error, which is twice the square root of the error mean square in the appropriate analysis of variance, divided by the square root of the number of observations averaged in calculating them.

REFERENCES

[11] "The Design of Experiments," by R. A. Fisher. Oliver and Boyd, 1937.
[13] "The Advanced Theory of Statistics," vol. II, by M. G. Kendall, Griffin and Company, Limited, 1946.
[13] Statistical Tables, by R. A. Fisher and F. Yates. Oliver and Boyd. 1938.

DISCUSSION

THE CHAIRMAN (MR. Colin Gresty) said that the Authors had mentioned the shot-blast chamber but he was not clear as to what they meant when they referred to the shot-blast area.

MR. MICHIE replied that the area in question was represented by a point chosen near to the shot-blast chamber—a matter of several yards away.

DR. H. T. ANGUS commented on the fact that in the Paper it was stated that, although samples had been taken from control points outside the foundry, they had not been considered in the final analysis. He could quite see that the research workers were mainly concerned with the distribution pattern inside the foundry itself, but in his experience, dealing with an iron foundry as distinct from steel, he had found on more than one occasion, where Owen's Jet counts were taken in the area outside the foundry, they were higher than those taken

inside. Such figures should be borne in mind, because although the dust-count was the same or higher outside it was presumably different in quality, and some notice of that should be taken. He would like to know whether any of the dust-counts were subsequently tested by heating in order to determine how much was organic and how much mineral.

MR. MICHIE replied that a certain number of the samples had been ignited afterwards, including both those at the control points and those taken within the foundries, but the results had been somewhat inconsistent. The picture was made more complex by virtue of the fact that the control points had been fixed in position during the course of the survey, so that it was apparent that the direction of the wind on a particular day, for instance, might have an appreciable bearing upon the control-point values determined. Whereas the direction of the wind on each day of the survey had in fact been reported, when it came to carrying out the analysis of the results, not only was the accuracy of these reports doubted, but to utilize them would have proved an extremely difficult task.

MR. JOWETT, also, in reply, added that the work which was presented in the Paper represented a task of calculation of some considerable magnitude. The question of control data had actually been raised, and some work had been done which suggested that the control data might partly account for some of the differences noted in the Paper. However, the workers had not yet reached the stage where they could include an analysis of control data and it was felt that "half a loaf was better than no bread."

Process Effects

DR. D. V. ATTERTON asked whether the Authors had found any variation in dust level when different techniques and practice were used, for example, according to the type of mould-wash that was being used or the size of the casting.

MR. MICHIE replied that up to the present time no attempt had been made to analyse the results systematically with this point in view. Generally speaking, insufficient data were available, and unless Mr. Jackson could add anything further, he himself would hesitate to draw any conclusions on this point.

MR. JACKSON added that it should be emphasized that the work in question had been planned with a limited number of objectives in view, primarily in order to ascertain whether surveys of that particular type were capable of objective analysis. The fact that, within the scope of the investigation, results had in fact emerged, must therefore be regarded as the principal outcome of the present work. It was possible, now this fundamental point had been established, that further surveys might be planned to cover specific points such as those raised by Dr. Atterton.

Hazardous Times and Places

MR. WELLS said there was no doubt that the figures given in the survey did give an indication of the worst times of the day and days in the week, so that they could, if they wished, apply corrective measures not all the time, but at particular times. Secondly, he wondered whether the Authors could give members any idea as to how the dust levels given in the Paper compared with the dust level in any street in the Conference area (Buxton) or on the Derbyshire moors; in other words, how much more dangerous were they than the ordinary sort of air which one breathed when away from the foundry?

MR. MICHIE replied that the difference between two actual dust-count figures, one obtained from a sample taken in a Buxton street and the other from a sample taken in a steelworks, was undoubtedly of less significance than the differences in constitution of the respective dusts. Even if the dust-count figures were as high in Buxton, he very much doubted whether the risk of silicosis would be as great as in a steelworks. One had to be wary of comparing hazards in terms of dust-count figures; the latter were obviously useful for control purposes and in investigations designed to lessen the hazard by reducing the quantity of airborne dust generated.

MR. STOKOWIEC remarked that apparently 9.30 a.m. was the worst time of the day, and it would be interesting to know whether the foundries were working three shifts or one. If they were working one shift a day, it meant that men starting in the morning were disturbing dust which had settled throughout the night, but if they were working three shifts, it seemed rather puzzling that the morning should be such a bad time of the day.

MR. MICHIE replied that, while this was an interesting point, they could do no more than make a guess at the reasons underlying the relatively high dust levels in the morning. As far as he was aware, none of the foundries surveyed was at the time operating a night-shift, and the theory that men going into the shop first thing in the morning might stir up dust which had settled on the floors and benches overnight had in fact been advanced by several people. In some cases, the effect could be accounted for by the lighting of open fires, but, in general, he was himself of the opinion that in any one shop the extent of the atmospheric contamination was determined by the activity associated with the dust-producing operations. In other words, the dust count might almost be regarded as an index of productivity!

MR. STOKOWIEC said he had noticed in the fettling shop they were not very willing to start work straight away, and the men usually blew air all over the place in order to clean the bench and castings before starting. They worked from about half-past seven until nine o'clock and then had a break for tea, and they probably did not so much produce dust as disturb that which was already there.

Plant Differences

MR. LUNT said it would appear quite evident that the fettling departments of the foundries which had been surveyed were the worst places, when one came to consider Table IV, relating to the mean dust level. At the same time, however, as the Authors had

rightly pointed out, there appeared to be quite a divergence between one foundry and another, and he wondered whether it would be fair to ask whether there was very much difference in the type of equipment being used in the various fettling shops in those foundries, and, if so, what types of equipment were used.

MR. MICHIE said he was not in a position to answer the question definitely, but to the best of his knowledge there had been no essential difference in the type of equipment being used. There would obviously be certain differences, some of which might no doubt effectively contribute to the differences in dust level observed.

MR. LUNT then asked how the Authors really accounted for the vast differences between, say, foundry II and foundry III, and Mr. Jackson replied that, at the present time, no attempt was made to account for it, and that only as the outcome of future work could one hope to provide the answer to this and other similar problems.

DR. ANGUS said that research workers in the particular field would have some sympathy with Mr. Michie because what he was obviously trying to do was to establish a method rather than to interpret results, and in that respect he was quite right. Inevitably, at first one found one had missed out information which ought to have been recorded, but one had to start somewhere. Undoubtedly, the further Mr. Michie and his co-workers went, the more results they would get and the more significance they would attach to auxiliary factors.

The CHAIRMAN said he still had some sympathy with Mr. Lunt, and his was undoubtedly a question which should be looked into. There was a very considerable difference between foundries II and III, and whilst the Authors might not know the data, they now knew the factors, and perhaps they could make further investigations and give a considered reply in the near future.

MR. JACKSON said that work was already well advanced in following up the inferences of the data recorded. The survey had served to point out some most important problems and workers were now busily engaged in attempting to solve them.

MR. MICHIE said that for this purpose, the surveys had a very limited number of objectives, and consequently one should refrain from attempting to draw too many conclusions. The design of the surveys had been shown unsatisfactory in certain respects, but much had been learned from the work and research workers now felt in a position to undertake future surveys with much more confidence.

Future Exploratory Work

MR. COUSANS expressed the opinion that the work of Mr. Michie and his colleague had been most valuable, but it was important to know what the next step was to be. It would be necessary to know the effects of casting conditions, types of steel used, casting temperatures and intricacy of castings as well as the effect of cleaning and dressing methods. Those who worked on the shop floor were keen to get rid of the dust-hazard but were waiting for some pointers as to the best means of tackling the problem. If Mr. Michie and his colleague would consider some of the other factors involved they would be performing a most useful service.

MR. MICHIE, in reply, said that these points were very much in mind, and as Mr. Cousans would be aware, the Research and Development Division's programme of research in this field was by no means confined to surveys of the type described. One thing learned during the course of the investigation, was the importance of consultation with the people who knew the local conditions pertaining in each individual foundry surveyed. Many facts might emerge from such surveys which might puzzle the investigators, but which could probably be readily explained by someone familiar with the conditions of working in the foundries concerned.

MR. JOWETT in considering literature relating to dust surveys in mines, and some other work done in foundries, had been struck very forcibly by the fact that many of the statistics were assembled without making note of the time of the day or the day of the week on which they were taken, and then the observations were lumped together rather haphazardly to give comparisons between one area and another. It was now established that the collection of data could not be carried out haphazardly. Account had to be taken of variation in the time of day and the pattern of variation through the week, even in such simple experiments as might be devised for comparing just one set of conditions with another. In that way, it was possible to attain a closer agreement between observations which were intended to be parallel.

Interpretation of Figures Collected

MR. LAWRIE (H.M. Engineering Inspector of Factories, Ministry of Labour & National Service) stressed what Dr. Angus had said: that the important thing was the establishment of a method and not so much a discussion of the results obtained in a particular foundry. He was especially interested because he bore some responsibility for that method.

He observed from the Paper that the Authors had accepted the suggestion that dust-counts would be more useful if they were recorded in group numbers on a geometrical progression and not in particles per ml., which had hitherto been the normal method of recording dust-concentrations, and it would be useful if the Authors would give more reasons for this method as against the rather older method of recording in particles per ml. He himself felt that they were right in their preference, but he would welcome further information.

A second point was the very surprising decrease in dust level at lunch-time, but because he knew the Authors had not given very careful thought to conditions in the foundry, so much as to the use of the method, and the value of the method, he was not going to ask why there should be a lunch-time decrease from the foundry viewpoint but rather from the scientific viewpoint. If one took Stoke's Law and applied Cunningham's correction one got a certain rate of fall for particles within the respirable-size ranges, from that it was clearly to be expected that those ranges would settle during a lunch-time break. Perhaps the Authors could give some

indication of the reason for such settling or—if he dared to suggest it—why they thought Cunningham's Law had not applied to foundry dressing operations.

Thirdly, he wondered whether Mr. Michie could tell members how to do dust surveys. He realized it was a question which could not be answered in two minutes, but Mr. Jowett had remarked that, in the past people had not paid much attention to the time of day or day of the week, and he felt it was most important that the people who were carrying out dust surveys should be given details, if their figures were to be used on a satisfactory statistical basis, particularly because, although he had developed part of the method, he had barely recognized it after it had been in the hands of the statisticians.

MR. JOWETT, replying to Mr. Lawrie's first point, said the use of a measure which was not quite an obvious one was not unprecedented in scientific investigations. Mr. Michie had drawn an analogy with the pH scale of measuring the degree of acidity or alkalinity of a solution. The *p*H value was the number normally employed to express the concentration of ionized hydrogen in an aqueous fluid, being in fact the logarithm of the reciprocal of the concentration. It represented a method of expressing activity which was better adapted for practical purposes than a straight-forward scale of hydrogen-ion concentration. Measurement on such an alternative scale was a device used constantly in statistical analysis; unfortunately it was a device the need for which was not always easy to explain, particularly if listeners were disposed to be sceptical. In this investigation, very high dust-counts tended to turn up occasionally; one group of half a dozen dust-counts might happen to include a count of 6,400 particles per ml., while another, taken under very similar circumstances, might by chance not include such a reading. The averages for the two groups would thus be overwhelmingly different, merely because of that one particular reading.

There was nothing sacred about the ordinary arithmetic average; it was used as a favourite measure for summarizing groups of observations, partly because it was taught at school and partly because it was very easy to calculate. Under the conditions of the investigation, half a dozen dust-counts were taken, it would often be found the average dust-count was far from typical; there might be five counts round about 600, and then a fortuitous puff of dust would give 6,000. Thus an average would resemble none of the counts. He hoped that these remarks would convince members that there was some justification for using the group-number scale, and so obtain averages which were reasonably typical of the set of readings which they were supposed to represent.

MR. MICHIE, referring to Mr. Lawrie's question relating to the fall in dust level during the lunch break, said that one suggestion which had been made was that it was due to convection currents removing the dust-laden air, rather than to the settlement or deposition of the particular matter. It was highly improbable that dust particles within the size-range sampled by the Owen's Jet would in fact settle in so short a time, and it therefore seemed more probable that either natural draughts or applied exhaust through the shop was responsible for removal of dust-laden air.

Need for a Concerted Plan

MR. LAWRIE expressed the opinion that the statisticians would do members very great service if they could tell how to carry out a dust survey which would give true indications of the conditions which existed in the foundry at any given time. He did not suppose they would be able to answer that question at the moment, but it was a very important point, and one to which he hoped attention in the future could be devoted in order to give the foundry industry a statistical method of sampling which could be relied upon to give a true answer as to the dust conditions.

To put more simply his first question, some years previously he had started estimating dust-counts by group number, and he now wanted to know, having had the assurance of a statistician that the method was a correct one, precisely why the statistician thought so.

Survey Statistics

MR. JOWETT, replying to Mr. Lawrie's last question, said that probably the best thing to do when one had designed a survey, especially a fairly ambitious one, was to consult a statistician. He did not advise asking a statistician to design the survey by himself; people had done that in the past and had regretted it because they received instructions which were difficult to follow in practice. The first thing to do was to decide on a few specific questions, and limit the aims of the survey to answering them. This particular survey had become very complicated, because it had set out with very wide terms of reference, namely, the general investigation of dust level in foundries. The investigators should preferably design a survey themselves, afterwards allowing a statistician to criticize it. It could then be re-designed in the light of those criticisms.

A survey should be kept as simple as possible by keeping the number of specific questions to a minimum. The simplest kinds of survey, carefully planned, could be analysed without expert statistical assistance, and in a matter of hours, not weeks. It was very important that a survey should be carried out strictly in accordance with its design, and that unambiguous instructions should be provided to tell the observers what to do, if some unfortunate accident prevented them from taking a reading exactly where they wanted to.

He could assure Mr. Lawrie that, on statistical grounds, group numbers were suitable measures of dustiness to use in the investigation of dust-levels. They might not be the best measures to use, but certainly would be better than the measures obtained by translating them into particles per ml. They might have practical disadvantages in some ways, being very dependent on an observer's interpretation of a picture, but from a statistical point of view their properties were very satisfactory.

THE CHAIRMAN asked if they were required to survey the six foundries again, were any particular recommendations or plans which the Authors would follow in order to avoid the pitfalls which they had met on the first occasion.

MR. JOWETT, in reply, pointed out that the Paper itself contained some constructive criticisms of the survey. In designing a survey along roughly the same lines, it would be better to take an observation at one of five times of the day instead of four, and vary the choice from day to day of the week at random. This would save a considerable time in statistical analysis and also minimize the damage done when one heading had to be missed. It would also be better to take direct account of fewer factors, the others being carefully taken at random. For example, if the differences between dust-levels at different times of day were of no immediate interest in an investigation where observations were to be collected at the rate of, say, six per day, it would be a good practice to choose the six times at random every day. Naturally, chance would affect the times selected on any particular day, but no time of day would be systematically omitted throughout the investigation; and overall averages calculated in the final analysis would then tend to take full account of all times of day, as well as being capable of being compared by means of reasonably simple statistical tests.

Average Conditions Required

MR. TIPPER said first, with regard to the statement that typical silicosis was caused by the inhalation of silica particles below 5 microns in dia., if the statistical research were based on this theory, the intention would be to measure such particles, and it would be interesting to know, in the light of the experience gained by the team, what was the simplest and most suitable method of doing that in order to obtain practical results. It was being attempted to measure something which was subject to many variables: the conditions in the foundry also varied very considerably, but to the individual working in the foundry those variations would always be there so that day-by-day conditions would have to be measured. Therefore, it seemed to him, speaking without experience, that what founders would have to compare was the overall picture and not just the conditions which existed at a particular time.

Reference was made in the Paper to some continuous methods of sampling, and to one which had been used by the Ministry of Fuel and Power, and he would like to know from Mr. Michie if those methods would not be more practical and give more useful information or whether he would recommend continuing with the Owen's Jet equipment used by an individual. Could not some equipment just be placed in position and left to work automatically?

MR. MICHIE, in reply, said that Mr. Tipper had put his finger upon an extremely important point and one which was appreciated by most people engaged in the field of dust-measurement. Regarding the particular surveys which formed the basis of the Paper, the second survey had of course been an attempt to obtain a more detailed picture of what was happening during the course of the day than had been obtained in the first. Even in this case, however, the number of samples taken was far from ideal, and the importance of continuous sampling could not be over-emphasized. The Research and Development Division of the B.S.F.A. hoped to develop equipment for this purpose and, of equal importance, equipment capable of assessing the records themselves. It was one thing to take continuous records and another to analyse them; consequently, consideration had also to be given to rapid, automatic methods of dust-counting. A technique designed to permit this was at present under development at University College, London, employing the instrument known as the "Flying Spot" microscope. This promised to provide a very rapid method of carrying out particle counts, and if the project met with the success envisaged, it would permit the automatic evaluation of dust-records in the form of continuous or intermittent deposits on a glass plate or strip. The technique also promised to provide a method for the analysis of particle-size distribution, a factor of considerable interest and importance. Although it was generally held that it was the particles below 5 microns dia. which were potentially of most danger, the relative importance of the different sizes below this was by no means clearly established, and the availability of adequate records of particle-size distributions was obviously a matter of some interest.

MR. JOWETT remarked that by having a continuous record, one of the uncertainties of the situation would be removed, namely, that due to having only a sample at set times. The continuous recorder would, however, have to be stationed at some definite point so that there would still remain the problems of choosing the position, and assessing its representativeness.

MR. COUSANS pointed out that although Mr. Michie had said that in some cases the dust was shown to be more toxic than others, as, for instance, in pneumatic-chisel fettling, he had also said there was no real correlation between toxicity of particles and particle size. Was there any means of estimating toxicity, because that was what founders were really interested in?

MR. MICHIE was sorry if some of his remarks had been misleading, because, although it was true that there was no absolute correlation between particle size and toxicity, in actual fact, both particle-size and shape were factors of considerable importance. As had been mentioned earlier, the most dangerous particles in a dust-cloud were generally recognized to be those less than 5 microns dia. The determination of the various factors governing toxicity had formed the subject of much research and the problem was inherently of a very complex nature. Reference had been made in Table I to an investigation being sponsored by the Research and Development Division, which had as its object the evaluation of the relative toxicities of dusts arising as a result of various steelfoundry processes. As part of this investigation, initial experiments had been conducted on rats and mice.

Denationalization of Iron and Steel

Bill presented to Parliament

The Government's Iron and Steel Bill was presented to Parliament on November 5. The preamble to the Bill states that its purpose "is to make arrangements for the future supervision of the iron and steel industry and to provide for the return to private ownership of the undertakings of companies owned by the Iron and Steel Corporation of Great Britain."

The Iron and Steel Act, 1949, is to be repealed, subject to certain, mainly transitional, savings. The Iron and Steel Corporation of Great Britain will cease to exist when it has prepared its final accounts. An Iron and Steel Holding and Realization Agency is to be established to take over all the property, rights, liabilities and obligations (except liability for British Iron and Steel Stock) of the Corporation.

Supervision of the Industry

An Iron and Steel Board is to be appointed by the Minister of Supply with the duty of generally supervising the industry, "with a view to promoting the efficient, economic and adequate supply of iron and steel under competitive conditions, and of keeping under review its productive capacity, raw material supplies, prices, and other matters." The Board's field is limited to the products of the activities specified in the third schedule to the Bill, which covers iron-ore working, the production of iron and steel, iron and steel founding, hot- and cold-rolling, forging, and the manufacture of hot-finished tubes, bright bars, tinplate and terneplate. New processes to produce similar products may also be added.

The Board is to consult with the industry with a view to securing necessary capital developments. If the Board thinks that capital development is necessary which the industry is unwilling to undertake, it is to inform the Minister. If the Minister thinks that development which the industry is unwilling to undertake is necessary, or that existing facilities should be kept in operation instead of being closed down, he may himself make the necessary provision.

The Board may in certain cases require schemes for the provision of additional production facilities to be submitted for its consent, which it may withhold if it thinks that the scheme would seriously prejudice the proper development of the industry. The Board is to consult with the industry with a view to ensuring that only schemes of major importance are required to be submitted for their consent. Enforcement is by injunction procedure, as if there were a contractual obligation to the Board not to proceed with such schemes without its consent. Where the Board's consent is withheld, appeal may be made to the Minister.

The Board is to consult with other bodies concerned, such as the National Coal Board, in relation to carbonization schemes.

Price Provisions

All iron and steel producers are to be under a duty to observe any maximum prices determined by the Board. The Minister in the national interest will have power to direct the Board to vary prices it has determined or to determine prices where it has not done so.

If the Board thinks that any raw material can with advantage be imported as a common service to the industry and that satisfactory arrangements do not operate for this already, it may arrange such importation. The Board may arrange imports of finished iron or steel if it thinks that supplies for home consumption are inadequate.

The following extract from the Bill referring to prices may be quoted:—

"For the purposes of this section, the products of an activity included or deemed to be included in the Third Schedule to this Act shall be deemed to remain the products of that activity notwithstanding that they have been subjected—

(*a*) to any process of heat-treatment, or

(*b*) to any process of coating other than vitreous, porcelain or stove enamelling, or

(*c*) to any process of corrugation, or

(*d*) to any process or operation, other than the machining of forgings and castings, incidental to the activity in question which in the opinion of the the Board should be treated for the purposes of this section as part of that activity, being a process or operation to which the products of that activity are commonly subjected by persons carrying on that activity,

not in any case being a process or operation comprised in an activity included or deemed to be included in the said Schedule; and the Board may determine different prices for the said products according to whether they have or have not been subjected to any such process or operation as is mentioned in (and not excepted from) any of paragraphs (*a*), (*b*), (*c*) and (*d*) hereof.

"Any maximum price determined under this section for any products may be determined so as to include or not to include a charge for delivery and, where it includes such a charge, the charge may vary according to the place of delivery, the method of transport, or any other variable factor affecting the cost of delivery."

The Board is to prepare a scheme for payment of levies by persons in the industry to finance the carrying out of the Board's functions. The Board may borrow money temporarily.

The Iron and Steel Holding and Realization Agency will be appointed by the Treasury and will have the duty of returning to private ownership the undertakings of the nationalized companies which will become subsidiaries of the agency on the appointed day. No time limit is set; pending disposal, the Agency is to promote the efficient direction of the companies. It may sell any securities which it holds. It is to have the normal powers of shareholders; in particular it may bring about the amalgamation, winding-up and capital reorganization of its subsidiaries, and the sale, lease or other disposal of assets of its subsidiaries. These and other powers to facilitate disposal are to be exercised with the consent of the appropriate Government department, which may give directions to the Agency. The Agency is to consult the Board before carrying out any regroupings of undertakings.

The Minister is to make regulations providing for compensation (*a*) to staff displaced as a result of the transfer of iron and steel companies to public ownership under the Iron and Steel Act, 1949, and (*b*) to staff displaced as a result of groupings and regroupings undertaken by the Agency in pursuance of their duty to return the companies' undertakings to private ownership.

When the Treasury considers the Agency's duty has been substantially discharged, it may by order dissolve the Agency.

British Cast Iron Research Association

Annual Report for the year ending June 30, 1952

[*Slightly Abridged*]

Yesterday, at the Waldorf Hotel, London, the British Cast Iron Research Association held its annual meeting at which the thirty-first Report on the Association's work was presented. It began with a brief review of the major events of the year under consideration—the opening of extensions to the headquarters' laboratories; installation of a Perkin-Elmer flame photometer, a Dietest dilatometer, an A.R.L. Quantometer and a grating spectrograph, all the latter purchased with the help of E.C.A. funds. Next, the proceedings of the previous annual meeting were reviewed, along with appointments made during the year and the technical functions attended by the senior executives. A note was included on the visit of members of the Department of Scientific and Industrial Research to the Alvechurch laboratories and the furtherance of the existing financial arrangements between the two bodies.

Research Department

Soundness of Castings

In connection with work on the soundness of iron castings, a study has been begun of the solidification of castings by means of thermo-couples inserted into the mould cavity. For this purpose, two 16-point Honeywell-Brown high-speed recorders have been acquired. A study has also been made of the atmospheric feeding of iron castings. Considerable experience has been obtained with the gamma radiography of defects. Apparatus has been constructed to permit the effect of gas evolution during solidification to be studied.

Graphite Formation

Work on the production of nodular cast irons has been concerned with the effect of elements which prevent magnesium from having the desired nodulizing effect. It has been shown that titanium, lead, antimony, aluminium and bismuth, and in certain cases also copper, can partly or completely prevent the formation of nodular-graphite structures. Further, it has been shown that the subversive effects of these elements can be completely neutralized by the addition of approximately 0.005 per cent. cerium. A comprehensive report on this work was published in the April, 1952, issue of the *Journal of Research and Development*. The study of the effects of other interfering elements and the neutralization of the effects of subversive elements by other rare earths is in hand.

Chemical Analysis

To meet the requirements of the work on nodular cast irons, chemical methods for the determination of very small amounts of lead, antimony and bismuth in cast iron have been developed. In addition, much co-operative work has been carried out on the standardization of chemical analytical techniques.

Enamelling

An investigation has been begun on defects occurring in vitreous-enamelled iron castings. The investigator has visited some 18 member-firms with the object of assessing the defects encountered in the industry, and a comprehensive report analysing the troubles has been prepared. With the co-operation of a number of member-foundries, considerable work has been carried out to determine whether machined surfaces of grey cast iron can be successfully enamelled. The original object of these field tests was to determine the source of enamelling defects, that is, to discover whether they are due to mould/metal reactions and inadequate cleaning, or whether they are due to the inherent properties of cast iron.

Spectrographic Analysis

Work on the calibration and use of the new spectrographic laboratory and the installation of a Quantometer and a diffraction spectrograph is in active progress. A method has been developed on the quartz spectrograph for the analysis of slags, and a comprehensive report giving details of the method appeared in the *Journal of Research and Development*, April, 1952. The method involves fusion of the sample with borax, together with cobalt oxide as an internal standard, followed by the pelleting of the fused mixture with graphite. By this method, the lime, silica, magnesia, alumina, iron oxide and manganese oxide contents of slags can be determined in about two hours, a considerable time saving on ordinary analytical methods. Further work has shown that the method may be used for the analysis of all oxide mixtures such as ores, refractories, etc., with a single standardization and independently of chemical analysis of standard samples. A method of evaluation was evolved in this laboratory in 1948, but was limited in its scope by the non-linearity of the low density end of the normal density-intensity relationship of photographic emulsions. The effects arising when this non-linear portion is used have been investigated, and the range of application of the method has been considerably increased. Spectrographic methods for the quantitative estimation of lead, arsenic, and antimony in cast iron have been devised and established for concentrations from 0.001 per cent. and upwards.

Gases in Cast Iron

Work on the determination of gaseous elements, and their influence in cast iron has continued. A satisfactory molten metal sampling technique has been developed for subsequent vacuum fusion estimation, and field tests using this technique have been carried out, covering a wide range of metal compositions and melting techniques used in the industry. The results have indicated considerable

British Cast Iron Research Association

variations in oxygen and nitrogen contents from plant to plant. Much work has been carried out on the effect of gas content on melting temperature. Methods of introducing nitrogen into cast iron have been studied and some preliminary information has been obtained on the influence of nitrogen in cast iron. A start has been made on the theoretical and fundamental appreciation of the factors influencing the solubility of oxygen in cast iron. An investigation of the gaseous elements has reached a stage where it is hoped that the work can be rapidly expanded in several promising directions.

Fatigue and Impact

For the programme of work on mechanical properties, six fatigue-testing machines have been constructed in the Association's workshop, and these machines are being used to study the influence of silicon content on the notch-sensitivity of nodular cast iron. An extensive investigation of the impact properties of various types of cast iron is in hand. In order to examine the usefulness of information given by an impact test on cast iron, the Charpy impact values on a number of different sized specimens from a wide variety of cast irons have been compared with the work done to fracture in a slow bend test. Notched and unnotched specimens have been tested. The effects produced by a reduction of testing temperature and notch have been compared. It has been found that to a large extent the impact and slow bend values give similar information for a flake-graphite iron. A considerable amount of work has been carried out on the impact properties of blackheart and whiteheart malleable cast iron, and nodular cast iron in the ferritic condition. The temper embrittlement of blackheart malleable cast iron and of ferritic nodular cast iron has been studied, and the effect of tempering treatments on the impact transition temperature has been determined. It has been shown that the transition temperature for notched ferritic nodular irons is related to the change in energy required to propagate a crack, whereas the transition temperature for unnotched specimens is related to the change in energy required to form the crack. In addition to the fundamental aspect, this work also has the object of devising standard methods of testing the impact properties of a wide range of cast irons, including malleable cast irons and nodular cast irons. Future developments will require co-operative work and may depend upon other laboratories obtaining suitable testing machines.

Moulding Sands

During the past year the new sands laboratory referred to earlier has been built and occupied. The shatter test has been studied, and the original test has been compared with three modified methods with the object of standardizing the test for foundry sand control. Futher work has been carried out on synthetic resins, and new resins have been tested for strength, gas content and stripping qualities. The brittleness of cores bonded with synthetic resins has also been studied. Apparatus constructed to measure this latter property is being tested. An investigation has been carried out on a new method for the rapid mechanical analysis of sand.

Work has continued on the study of the load-deformation curves obtained on various types of sand at room temperature. The object of this investigation was to develop a new method of assessing the tendency of a moulding sand to produce scabbing defects in the casting. Correlation was found between the form of the stress-strain curves and the scabbing tendency of any sand, other than those containing materials such as pitch and coal-dust. Such materials appear in particular to influence the properties of sands at the temperatures they are required to meet in service. An attempt is being made to develop an apparatus to permit similar tests to be carried out at elevated temperatures. This apparatus incorporates a di-electric heater operating at 100 megacycles and preliminary tests have been made.

A fundamental study of the flowability of moulding sands has been carried out, and tests for this property have been investigated and related to a useful theoretical concept. A comprehensive report on this matter will be issued.

Propeller Corrosion

Further laboratory and field tests, carried out in conjunction with the British Shipbuilding Research Association, have demonstrated that the pitting of cast-iron ship propellers is not primarily due to the mechanical action of bubble collapse, but is mainly due to an accelerated form of corrosion. On this hypothesis, attempts have been made to protect cast-iron ship propellers by cathodic means, using either an applied potential with a graphite anode or a sacrificial anode of magnesium. The latter method has proved successful, and attempts are being made to improve the design and method of fixing to give a longer life. Tests with protective coatings on ship propellers have proved fairly successful and further work is in hand. Further tests have been carried out in connection with the North Cotswold Rural District Council's cathodic protection scheme for buried pipes.

Chilling

An investigation has been proceeding on the factors influencing the chilling tendency of cast irons. Although comparatively small from the point of view of tonnage output, chilled and white cast irons have a high technical importance. A suitable chill-test has been developed and a study has been made of the effect of dry- and green-sand moulds and chill coatings. The effect of pre-heating temperature and holding time on chill formation has been investigated. It appears possible to infer from this work that variations in gas content, particularly oxygen, have only a minor effect and that the influence of melting temperature is primarily a nucleation effect. The inoculating effects of graphite and other small modifying additions have been studied. It has been shown that small additions of inoculants such as ferro-silicon or aluminium have a slight tendency to increase the chill. An extensive study has been made of the influence of manganese and sulphur contents in relation to cast-

ing temperature on chill and mottle formation. The influence of melting stock on chill and mottle formation has also been studied and it has been shown that a white-iron base material has a different effect on chill formation from a grey-iron base material of the same composition. A report on this work is in course of publication.

Work has been begun on the mechanical properties of white cast iron. The development of suitable methods of casting and preparing test-pieces has been studied and preliminary work on the effect of melting temperature and carbon content on mechanical properties of white cast iron has been carried out.

Development Department

Work in the development department has been pursued on lines indicated in previous reports and many technical enquiries from members and others have been dealt with. Not only has the number of visits paid by the staff of the department to member-firms in connection with these enquiries increased, but also the time spent on them, with very satisfactory results. Enquiries relating to the engineering uses of cast iron continue to be dealt with. Members of the staff have been called upon to give lectures throughout the country on various aspects of the foundry industry.

Work has also been continued on specific problems. A lengthy programme of work on the welding of cast iron has been concluded, and the report is now in the hands of the committee. A series of examinations has been carried out on machine-tool and lathe beds throughout the country, and microstructures, analyses and hardnesses have been taken on machines actually in service, so that a comparison of the wear-resistance of different grades of iron can be made. This work is also in the report stage. An investigation on the magnetic properties of cast iron related to their structure has also been completed, and a paper dealing with the strength, structure and composition of unalloyed grey iron was read before the Institute of British Foundrymen in June.

Foundry Atmospheres

The work of the foundry atmospheres team has continued on an increasing scale. In September, 1951, a conference on heating, lighting and ventilation for ironfoundries was held, and attended by 170 people. The subject of ventilation of buildings, types of equipment to be employed, the discharge of dust from grinding wheels, lighting, heating and spark arresters were dealt with. This conference aroused a great deal of interest in the industry.

An important investigation dealing with the discharge of fine dust-particles from grinding wheels has been carried out, and a completely new system of exhaust ventilation put forward. This work has been filmed by the Association in conjunction with the Inspectorate of Factories, and the results have been communicated to the industry.

An investigation of the effect of spark arresters, both on the discharge of dust outside the foundry and their possible effect on the discharge of carbon monoxide on to the cupola platform, has been undertaken, and much data obtained. It is hoped ultimately to be able to formulate a code of practice dealing with the installation of such equipment.

An investigation of the production of carbon monoxide from mould driers has been in progress during this period and is now completed, and the report is in preparation. Further work on the evaluation of methods for the control of dust from items of equipment has been carried out, and a short investigation on the limiting moisture requirements to prevent dust formation from sand has been completed. In conjunction with the Building Research Station, a complete survey was taken of the air movement and temperature gradients in a small foundry over a period of some weeks. Repeated requests are received for advice on specific ventilation matters, and this is given whenever it is possible to do so without interfering with the programme of work laid down by the Committee.

U.S. Consultant.—Through the courtesy of the Mutual Security Agency, and its predecessor the Economic Co-operation Administration, the services of an American foundry consultant were made available to British foundries during the year. The industry was asked by the Joint Iron Council to make formal requests for visits through its trade associations. Thus, while the Association was in no way responsible for the selection of the foundries visited, the whole of the subsequent schedule and arrangements for the visits were undertaken by the Association, which arranged for the attendance of a member of the development staff to facilitate the work. In this way 82 visits were paid to 64 foundries before the consultant was withdrawn for service in other parts of Europe, and it was generally felt that the visits were extremely stimulating and had served a very useful purpose.

Scottish Laboratories

In the year ended June 30, 1952, 360 enquiries were received, involving 134 actual visits to foundries. The work in the chemical laboratory shows a slight increase over the previous year, but the demand for mechanical tests and micro-examinations has fallen off. In general, however, the number of enquiries is still more than double that in 1950.

Operational Research Team

The operational research team was augmented from three to five members in February, 1952. Groups consisting of two or three of these visit foundries of member-firms by invitation, and, when necessary, visits by individual members of the team are arranged to deal with specific problems. During the year under review, 126 visits were made. The work done by the team since its inception in June, 1950, to June 30, 1952, is given as:—Team visits 141; special visits by team or individual members, 40; return visits 31 and special reports 4; total 216. The number of requests for new visits outstanding is 80 and the number of return visits requested and not yet made is 35.

To the end of September, 1952, the number of visits paid is 264, and the number outstanding for attention is 121, the requests having been received

British Cast Iron Research Association

since the end of the financial year at a slightly greater rate than they can be fulfilled. An encouraging feature of the foregoing figures is the large number of requests received for return visits, and it is known that a number of firms are using the team's report as a basis for long-term planning and reorganization.

The main purpose of the team is to submit a confidential report suggesting such a long-term policy which may be put into effect over a number of years. Diagrammatic sketches for discussion purposes are submitted when necessary, with emphasis on simplicity and economy of lay-out.

The team also deals with technical details as far as time permits, but problems which require closer study are passed on to the development department for further consideration.

Intelligence Department

Thirty research reports were published in the *Journal of Research and Development* (now in its eighth year) during the year. The *Bulletin* has appeared at regular intervals, and in addition to the usual abstracts section, has published lists of annotated references to subjects of topical interest such as the shell-moulding process and methods of effecting carbon pick-up, and has also published a catalogue of selected films on foundry and related subjects.

Six external reports (chiefly consisting of papers presented by members of staff to other bodies) and 36 translations of foreign papers were issued during the year.

The collection of photomicrographs of representative cast irons with an explanatory text, published at the end of 1951 under the title, "Typical Microstructures of Cast Iron," prepared by a member of the development staff, was very well reviewed and more than 1,000 copies have been sold in this country and overseas, particularly in Scandinavia and the Netherlands.

To meet the growing number of inquiries on the properties of cast iron, a number of reprints from Kempe's Engineer's Year-Book of the data referring to cast iron (originally supplied by the Association) have been obtained for circulation.

The conference on heating, lighting and ventilation for Ironfoundries, held at Ashorne Hill in September, 1951, was well attended and aroused the interest not only of members but also manufacturers of equipment. The collected proceedings of this conference have obtained a wide sale. The collected proceedings of an earlier conference on malleable iron have also been published.

The Association participated with the C.F.A. in organizing and staffing a stand at the Engineering, Marine and Welding Exhibition at Olympia in September, 1951. The Association also took an active part in the C.F.A. conference at Ashorne Hill in March, 1952, on recruitment, education and training for the industry, the report on which has since been issued. The intelligence department has acquired more space as a result of extensions elsewhere. A basement has been converted to a stock room to house sets of periodicals, and the department now forms a compact, self-contained unit.

Library loans, and accessions of new publications the given as follow:—*Library Loans*: books 859; periodicals 1,956 and pamphlets 855. *Library Accessions*: books 171; new periodicals 5 and pamphlets 527.

Education and Training

The National Foundry College continues to develop. Mr. P. H. Wilson, O.B.E., past-president of the Association, has been elected chairman of the Board of Governors, following the greatly regretted death of the late Mr. R. G. Hoskins, C.B.E., and the director, Dr. J. G. Pearce, has been elected vice-chairman.

The short courses on sand-testing and control referred to in the last report have been completed and the time will shortly be ripe for their continuation, at the same level of instruction. The desirability of an advanced course for those who have already attended the first course is under consideration. These courses have given over 100 members of the industry the most up-to-date basic instruction on the properties and control of moulding sand.

Finance and Membership

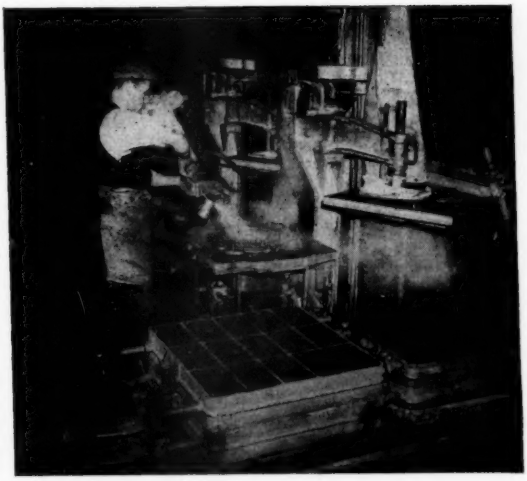
The statement of accounts and balance sheet indicate income at a record figure, but the expansion of activity in recent years, the continued growth of membership and the marked increase in prices for supplies, services and salaries has brought expenditure to the limit which is permissible with the present income. A budgeting system has been installed, fixing the limits of expenditure for each phase of activity. The total number of members of the Association in all classes as at June 30, 1952, was 1,272, representing an increase of 33 during the year.

The report is signed by Dr. J. E. Hurst, president; Mr. J. J. Sheehan, chairman of Council, and Dr. J. G. Pearce, director.

New Catalogues

Shell-moulding Process. Monsanto Chemicals, Limited, Allington House, Allington Street, London, S.W.1, have sent us Production Information Bulletin No. 77, "The Shell-moulding Process," issued by their American associates. This publication ranks amongst the most interesting issued to our industry. Whilst much is now known about shell moulding in this country, no printed information is known which gives such a good description of the process or presents so much valuable data. For instance, eight firms—American, of course—are listed who have developed "shell-moulding machines and ancillary equipment." No wonder productivity is high where such enterprise is shown. The brochure also lists the sources of suitable (American) sands. As there are no copies available for distribution in this country, it is suggested readers write to the Monsanto Chemical Company, Plastics Division, Springfield 2, Massachusetts, U.S.A., for the favour of a copy, mentioning that the FOUNDRY TRADE JOURNAL suggested this approach.

A DELEGATION from India left for Washington on November 1 to negotiate a loan from the World Bank for the establishment of a State steelworks.



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Personal

MR. BRYAN DONKIN, M.I.C.E., has been elected chairman of the Council of the Engineers' Guild and Mr. W. A. M. Allan, M.I.C.E., as chairman of the executive committee.

MR. M. W. HUMPHREY DAVIES has been appointed to the University Readership in Electrical Engineering tenable at the Imperial College of Science and Technology, London.

MR. E. L. TOLSON, chief wages clerk of the Cleveland Bridge & Engineering Company, Limited, Darlington, has retired after more than 51 years' service with the company.

MR. J. A. WATT has been appointed repair manager at the Southampton establishment of Harland & Wolff, Limited, the Belfast shipbuilders, in place of MR. G. H. ALLEN, who is retiring.

MR. L. ATHERTON, B.Sc., A.M.I.E.E., has recently joined the equipment division of Mullard, Limited, to take charge of the special products commercial group. This group specializes in ultrasonic equipment and laboratory and industrial applications of electronic techniques.

DR. OWEN WANSBROUGH-JONES has been appointed to succeed SIR HARRY GARNER, the chief scientist of the Ministry of Supply, when he retires in the New Year. Dr. Wansbrough-Jones, who is 47, has been principal of Scientific Research (Defence) in the same Ministry since January, 1951.

MR. K. M. FOX, until recently in charge of the Bristol district sub-office of the British Thomson-Houston Company, Limited, has been appointed manager of the company's Swansea district office in succession to Mr. S. J. CLARKE, who will shortly be taking up another appointment in the B.T.-H. organization.

SIR JOHN MAUD, who recently succeeded Sir Donald Fergusson as Permanent Secretary of the Ministry of Fuel and Power, has been appointed a member of the Economic Planning Board. The Permanent Secretary to the Ministry of Materials, SIR JAMES HELMORE, succeeds Sir Alan Hitchman as a member of the Board.

MR. ARTHUR DORMAN, a director of Dorman, Long & Company, Limited, chairman of British Structural Steel Company, Limited, and other companies, and a director of several companies, including Darlington & Simpson Rolling Mills, Limited, and Redpath, Brown & Company, Limited, and a director of the British Iron & Steel Corporation, Limited, has been elected president of the Cleveland Scientific and Technical Institution. He succeeds MAJOR W. R. BROWN, a director of Ashmore, Benson, Pease & Company, Limited. MR. E. T. JUDGE, an executive director of Dorman, Long & Company, Limited, has been re-elected vice-president, and Mr. W. L. FLETCHER, managing director of Tees Side Bridge & Engineering Works, Limited, junior vice-president.

A.F.S. Meeting.—The next annual meeting of the American Foundrymen's Society will be held from May 4 to 8, in Chicago.

J. Ainsborough Everiss and Associates, of 157, Victoria Street, London, S.W.1, inform us that their telephone numbers are now Tate Gallery 9191 and 9226.

Obituary

MR. J. F. DRIVER, editor of "Machinery-Lloyd," died recently at the age of 70.

MR. JOHN DYSON, who died recently, was a director of Fredk. Dyson & Sons, Limited, ironfounders, of Leeds.

MR. HENRY SWIFT LEVICK, chairman of Swift Levick & Sons, Limited, steel manufacturers, of Sheffield, died on November 4, at the age of 73.

MR. NORMAN ATKINSON DOWSWELL, chief designer of Sheepbridge Engineering Limited, founders and engineers, of Chesterfield, died recently at the age of 56. He went to Chesterfield 2 years ago as chief draughtsman of the Sheepbridge Coal & Iron Company, Limited.

THE DEATH is announced of MR. W. R. LONG at the age of 71. From 1921 to 1927 Mr. Long was advertising manager of this JOURNAL; he left this position to become manager of the London office of Stewarts and Lloyds, Limited—a position he held until his retirement some six years ago. He will be greatly missed by the older members of the industry, on account of his invariable cheerfulness, his kindliness, worldly wisdom and apt philosophical interjections. He leaves a widow and four children.

British Productivity Council

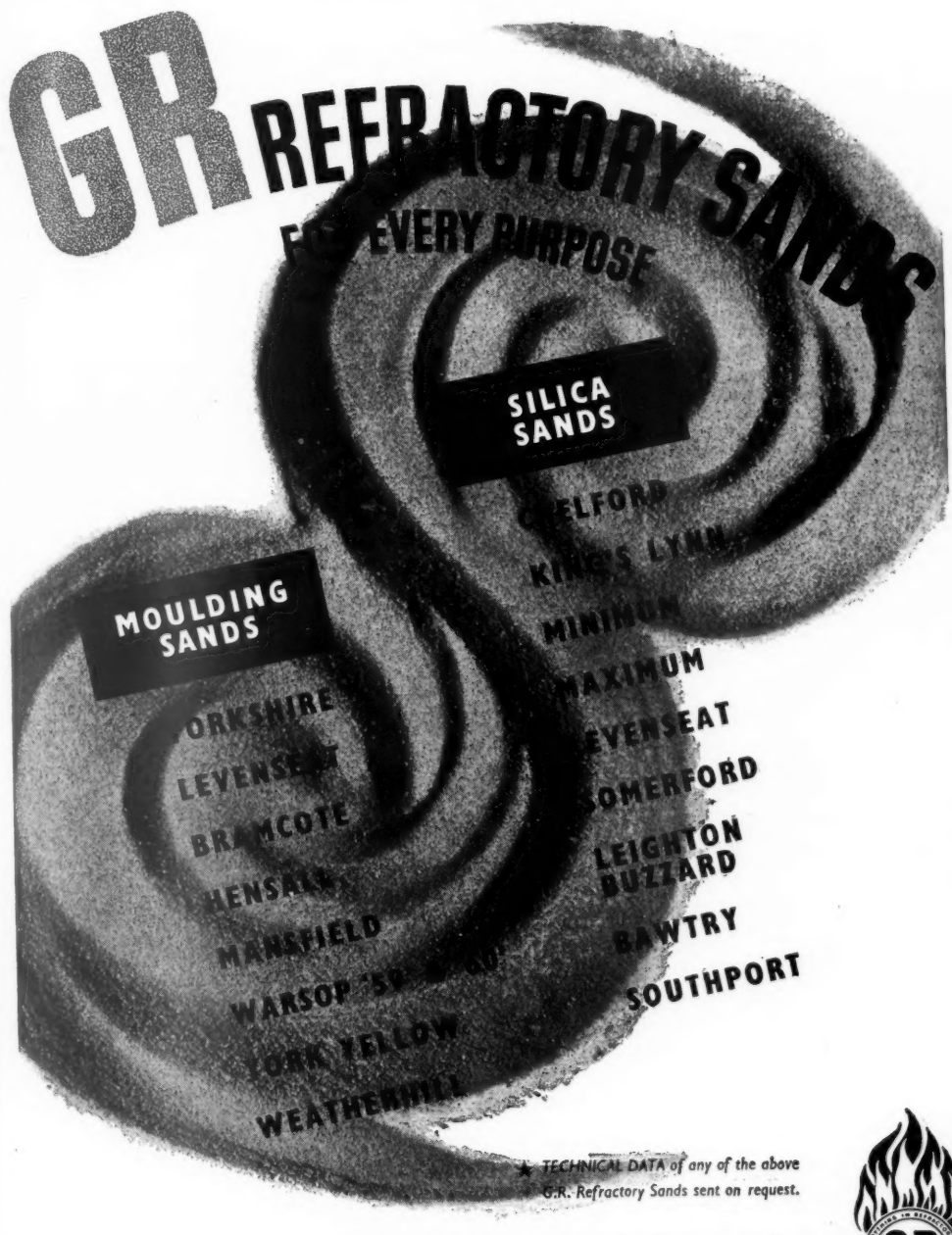
The British Productivity Council is to take over the work of the British section of the Anglo-American Council on Productivity, which completed its main activities this summer. It was formally established in London on November 4. Sir Peter Bennett, former Parliamentary Secretary to the Ministry of Labour, was appointed chairman, and Mr. Lincoln Evans, chairman of the Trades Union Congress economic committee, was appointed deputy chairman.

The Council's programme will be determined at a meeting early in December. Its principal aim is "to engage the active interest of industry in the pursuit of higher productivity and to give it all possible help in its independent activities."

In addition to representatives of the British Employers' Confederation, the Federation of British Industries, and the Trades Union Congress—the constituent bodies of the A.A.C.P. since its inception three and a half years ago—the Council includes representatives of the Association of British Chambers of Commerce, the National Union of Manufacturers, and the nationalized industries. Each of the participating bodies will subscribe directly to the funds and, subject to Parliament's approval, a Government grant will also be available.

I.C.I.'s Titanium Plant

In connection with its three-year research and development programme covering the manufacture of titanium, Imperial Chemical Industries, Limited, announces that this work has reached a stage where the company can immediately start to erect pilot plants for the production of wrought titanium and its alloys. When these plants are in production, it is pointed out, they will provide a British source of supply for the development of prototype applications in the engineering and aero-engineering fields.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News in Brief

NEXT MONDAY, the export manager of Lancashire Dynamo & Crypto, Limited, Mr. A. J. C. MacLeod, A.M.I.E.E., will be leaving London for an extensive business tour of Pakistan, India, Ceylon and Cyprus.

THE FORMER naval submarine depot ship Montcalm, which has been laid up in the Gairloch for the past two years, has been sold by the Admiralty and has been towed to Faslane for breaking-up by Metal Industries, Limited.

THE MINING COLLECTION at the Science Museum, South Kensington, will be reopened in much enlarged form by the Right Honorable Geoffrey Lloyd, P.C., M.P., Minister of Fuel and Power, on November 18. It will be open to the public free of charge on and after Wednesday, November 19.

NOTICES are being issued dismissing 175 operatives as redundant at the Birmingham works of the Singer Motors Company, Limited. Those affected include sheet-metal workers, engineers and vehicle builders. The company attributes the redundancies to lack of sales with consequent increase in stocks.

F. & M. SUPPLIES, LIMITED, held a convention at the Great Eastern Hotel, London, on November 10, to launch a new type of core-binder they are about to market. After lecture and demonstration, the sales representatives were entertained to lunch and made a tour of the company's works at Poplar.

THE SOUTHERN SECTION of the Institution of Production Engineers have arranged a conference on "Problems of Aircraft Production," to be held at the University of Southampton, on Friday and Saturday, December 19 and 20. Details may be obtained by writing to the I.P.E. Secretariat at 36, Portman Square, London, W.1.

ACCORDING to the *American Foundryman*, the "Green" tour, organized in connection with next year's International Foundry Congress (to be held in Paris from September 21 to 27) starts from Paris at the conclusion of the conference and takes in Italy, Switzerland, Germany, Belgium and England. It will last about 40 days. So far, more than 280 American registrations have been accepted.

THE LORD MAYOR OF BIRMINGHAM, Ald. W. T. Bowen, accompanied by the Lady Mayoress, opened the exhibition staged in Birmingham in connection with the annual conference on November 6 of the Sheet and Strip Metal Users' Technical Association. The president of the Association, Mr. W. H. Grainger, said that it was the first time the Association had held its exhibition in Birmingham in its life of seven years. Twenty-two firms exhibited. Of the 400 member firms of the Association, 143 were located in the Midlands.

THE BIRMINGHAM AND DISTRICT INDUSTRIAL SAFETY GROUP is to hold a second Safety and Factory Efficiency Exhibition at Bingley Hall, Birmingham, from June 19 to 26 next year. The forthcoming exhibition will be wider in scope than last year's and 70 stands will show many aspects of the work of promoting safety, efficiency and health in industry. During the exhibition, the Group will hold a conference on safety and health training. The chairman of the Group's exhibition organizing committee is Mr. R. Bramley Harker, H.M. superintending inspector of factories for the south-Midland region.

OVER A HUNDRED YEARS AGO the firm of John Gray, Uddingston, turned out the first iron plough in the world. To-day George Gray & Company, run by Mr. Charles Gray, great-grandson of the founder, in partnership with Mr. James B. Dick, are producing support stands and transport trollies for jet engines and racks for the building of Centurion tanks. The original works, which produced horse-ploughs exclusively, were established in 1835 and were situated on land now occupied by the railway goods yard and local bowling club. Present works are in Old Mill Road. The first iron plough, Mr. Gray told our local correspondent, is in a museum somewhere in America. Recently the owner was offered £1,500 for it, but turned the offer down.

AT A RECENT MEETING, the Council of the Birmingham Chamber of Commerce heard details of a survey that has been undertaken and which reveals that the Federal German Goverment has adopted a comprehensive system of incentives for exporters. They include preferential allocations of raw materials, an export-sales bonus and tax concessions. Also, a new scheme has been introduced in Germany to promote exports to the dollar area. The German exporter to the dollar area receives as "import right" equal to 40 per cent. of the gross effective proceeds of the contract and this right enables him to cut prices. Trade with Latin America and other countries would soon vanish unless the problem of assisting exporters was tackled with the greatest urgency, the Council was told, and it was stated that the matter had been referred to the Association of British Chambers of Commerce, which had, however, recommended that no official subsidization of exports was desirable in this country and that the Government could best assist by freeing industry from controls. Mr. C. A. F. Hastilow, chairman of the General Purposes Committee, said that his committee felt that the action of the Association did not go far enough to the root of the problem. His committee would make strongest representations to an *ad hoc* committee to be established by the Association.

European Foundry Productivity Symposium

The first meeting of European foundrymen to discuss methods of increasing foundry productivity opened in Paris on November 5, under the auspices of the Organization for European Economic Co-operation. At this meeting, which was arranged by the *Centre Français de Productivité and the Syndicat Général des Fondeurs de France*, foundrymen from the member countries of O.E.E.C. discussed the methods employed to improve productivity, the difficulties encountered, and the developments and improvements already achieved in European foundries. The meeting also analysed the practical results obtained by national and international technical-assistance missions after studying foundry productivity in America, and as a result of the visit of American experts to Europe.

This meeting, the first to be organized in Europe, was held at the headquarters of the *Syndicat Général*, 2, rue de Bassano, Paris (16e) from November 5 to 8. Eighty-five delegates representing foundry associations and firms which have carried out productivity tests, as well as experts who have studied foundry productivity in the United States, were present. The British contingent at the meeting included Mr. N. P. Newman, Mr. K. Marshall, Mr. J. W. Butler (secretary), Mr. Frank Hudson, Mr. S. H. Russell, Mr. A. McDougall, and Dr. H. T. Angus.

BX15

Dear Sir...

. . . INTRODUCING myself should hardly be necessary seeing that so many already know my relation to borax, boric acid and a host of other boron products used in industry and in the home. The time has arrived, however, for me to come out into the limelight and say something more about myself, where I am found, what I do and how I do it.

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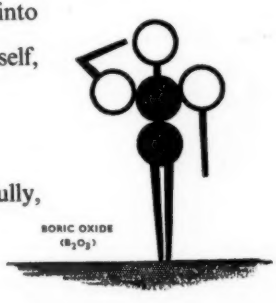
Yours faithfully,



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Raw Material Markets

Iron and Steel

The volume of work available to the foundry industry has shown a sharp recession in recent weeks, with the result that most establishments are endeavouring to implement their order-books to ensure continuity of production. Very few foundries remain unaffected by the changed conditions, which have resulted from depleted export business and reduced demands from home consumers, but those catering for the Diesel engine, tractor, and textile industries, and the light foundries producing castings for household equipment are chiefly affected. Many foundries are, of course, engaged on rearmament work and they are able to maintain normal production levels.

Only a short time ago, foundrymen were confronted by large arrears of orders—a legacy of raw material shortages. These areas have been practically eliminated and outputs are almost solely dependent upon day-to-day bookings. Unless there is an improvement in trade in the near future production of castings will be considerably reduced.

With satisfactory supplies of iron ore and better deliveries of coke, pig-iron production is maintained. Although the pig-iron requirements of the foundries have declined, the demand from the steelmakers shows no abatement; they are taking all the basic pig-iron which the furnaces can supply. Deliveries of scrap to the steelworks fall well short of the quantities required, and while the steelmakers' position has been eased greatly by increased deliveries of pig-iron, additional tonnages of scrap are urgently needed. The foundry grades of pig-iron are, in the main, sufficient for present needs. But supplies are none too plentiful and any appreciable increase in the demand would be difficult to meet. Many of the light and jobbing foundries, which utilize the high-phosphorus grade, still cannot obtain their full requirements owing to reduced outputs caused by the blowing-out of furnaces for re-lining and repairs.

Scrap supplies for the foundries are on a better scale. Foundry coke is received in sufficient quantities to cover current consumption, with some to spare for stock, while ganister, limestone, and firebricks are readily available.

Home demands for bars, small sections, and strip are enabling the re-rollers to obtain reasonable outputs. Apart from sheets, very little export business is on hand, particularly for small bars, orders for which are unobtainable on account of the severe competition from foreign producers. The sheet re-rollers are well occupied with orders for both home and export markets. Deliveries of steel semis are, in the main, satisfactory, with good tonnages coming into the country from oversea. Home steelworks are sending forward all available supplies, but the re-rollers could take much larger tonnages.

Non-ferrous Metals

The strike of African mineworkers on the Northern Rhodesian copperbelt has ended, and production was resumed on Monday last. Production had been in abeyance since October 20. Negotiations in the wage dispute which led to the stoppage were resumed on Tuesday. About 37,000 men were affected by the strike.

In view of the Government's announcement about the disposal and distribution of lead stocks, the figures published by the Bureau of Non-ferrous Metal Statistics are more than usually interesting. These cover the month of September and show that at the end of that month the Government held some 96,000 tons, while the consumers' holding was about 13,500 tons. In total there was a fall of about 7,000 tons on a month earlier. Consumption of lead, virgin and secondary, was 24,902 tons, compared with 18,542 tons in August. In zinc there was a further increase of about 9,000 tons in total stocks to 133,699 tons, which compares with about 40,000 tons at the beginning of the year. Consumption, all grades, in September amounted to 21,192 tons, against 16,511 tons in August. Copper stocks were virtually unchanged at 121,649 tons, but consumption was up by about 10,000 tons to 49,000 tons, of which 28,303 tons comprised virgin metal. At 438,380 tons usage during the first nine months of this year is about 30,000 tons better than in the corresponding period of last year. Consumption of tin in September totalled 1,789 tons.

The decision to transfer the balance of lead stocks, not required for stockpiling and current sale to consumers, to the producers, has been interpreted for the most part as a bull factor, but the recent strength of the market was probably due much more to the ½ cent rise in the United States. It has been suggested that American buying has supported the London lead market, and this may be true. From the Government's statement it appears that the hand-over to the producers will be spread over about 14 months on the basis of the average price obtaining month by month. This seems a sound arrangement, and although the total involved can only be a matter of guesswork, it is thought that the long period of absorption will militate against the tonnage proving to be in any way onerous. Current estimates are that the tonnage taken in to the stockpile is fairly heavy.

Official prices for refined pig-lead were:—

November—Thursday, £95 to £95 10s.; Friday, £93 5s. to £93 10s.; Monday, £96 to £96 10s.; Tuesday, £96 5s. to £96 10s.; Wednesday, £97 10s. to £97 15s.

February—Thursday, £95 to £95 10s.; Friday, £93 5s. to £93 10s.; Monday, £96 to £96 5s.; Tuesday, £96 to £96 10s.; Wednesday, £97 10s. to £97 15s.

Official tin quotations were as follow:—

Cash—Thursday, £962 to £963; Friday, £958 to £958 10s.; Monday, £957 to £958; Tuesday, £955 10s. to £956; Wednesday, £952 to £953.

Three Months—Thursday, £942 to £943; Friday, £940 to £941; Monday, £940 to £941; Tuesday, £938 10s. to £939 10s.; Wednesday, £935 to £936.

Institute of Metals Officers

The following members have been elected to fill vacancies on the Council of the Institute of Metals with effect from the 1953 annual general meeting: *as president*: Professor F. C. Thompson (Professor of Metallurgy, University of Manchester); *as vice-presidents*: Major C. J. P. Ball (chairman, Magnesium Elektron, Limited) and Professor G. V. Raynor (Professor of Metal Physics, University of Birmingham); *as members of Council*: Mr. W. A. Baker (research manager, British Non-Ferrous Metals Research Association); Mr. J. C. Colquhoun (chairman and managing director, Manganese Bronze & Brass Company, Limited); Mr. E. R. Gadd (chief metallurgist, engine division, Bristol Aeroplane Company, Limited), and the Hon. John Grimston, M.P. (director and general manager, Enfield Rolling Mills, Limited). The Council of the Institute has elected Dr. S. F. Dorey (chief engineer surveyor, Lloyd's Register of Shipping) to serve as senior vice-president for 1953-54, and he will be their nominee for the presidency in 1954-55.

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Current Prices of Iron, Steel, and Non-ferrous Metals

(Delivered, unless otherwise stated)

November 12, 1952

PIG-IRON

Foundry Iron.—No. 3 IRON, CLASS 2:—Middlesbrough, £13 1s. 6d.; Birmingham, £12 15s. 3d.

Low-phosphorus Iron.—Over 0.10 to 0.75 per cent. P, £16 8s., delivered Birmingham. Staffordshire blast-furnace low-phosphorus foundry iron (0.10 to 0.50 per cent. P, up to 3 per cent. Si), d/d within 60 miles of Stafford, £15 5s. 9d.

Scotch Iron.—No. 3 foundry, £15 19s. 6d., d/d Grangemouth.

Cylinder and Refined Irons.—North Zone, £17 14s. 6d. South Zone, £17 17s.

Refined Malleable.—P, 0.10 per cent. max.—North Zone, £18 14s. 6d.; South Zone, £18 17s.

Cold Blast.—South Staffs, £18 2s.

Hematite.—Si up to 2½ per cent., S. & P. over 0.03 to 0.05 per cent.:—N.-E. Coast and N.-W. Coast of England, £16 2s.; Scotland (Scotch iron), £16 8s. 6d.; Sheffield, £17 3s.; Birmingham, £17 9s. 6d.; Wales (Welsh iron), £16 8s. 6d.

Basic Pig-iron.—£13 19s. all districts.

FERRO-ALLOYS

(Per ton unless otherwise stated, delivered.)

Ferro-silicon (6-ton lots).—40/55 per cent., £57 10s., basis 45% Si, scale 21s. 6d. per unit; 70/84 per cent., £86, basis 75% Si, scale 23s. per unit.

Ferro-vanadium.—50/60 per cent., 22s. per lb. of V.

Ferro-molybdenum.—65/75 per cent., carbon-free, 10s. per lb. of Mo.

Ferro-titanium.—20/25 per cent., carbon-free, £204; ditto, copper-free, £212.

Ferro-tungsten.—80/85 per cent., 27s. 6d. per lb. of W.

Tungsten Metal Powder.—98/99 per cent., 30s. 8d. per lb. of W.

Ferro-chrome (6-ton lots).—4/6 per cent. C, £85 4s., basis 60% Cr, scale 28s. 3d. per unit; 6/8 per cent. C, £80 17s., basis 60% Cr, scale 26s. 9d. per unit; max. 2 per cent. C, 2s. per lb. Cr; max. 1 per cent. C, 2s. 2½d. per lb. Cr; max. 0.15 per cent. C, 2s. 3½d. per lb. Cr; max. 0.10 per cent. C, 2s. 3¾d. per lb. Cr; max. 0.06 per cent. C, 2s. 4d. per lb. Cr.

Cobalt.—98/99 per cent., 20s. per lb.

Metallic Chromium.—98/99 per cent., 6s. 5d. to 6s. 9d. per lb.

Ferro-manganese (blast-furnace). — 78 per cent., £49 0s. 8d.

Metallic Manganese.—93/95 per cent., carbon-free, £262 per ton.

SEMI-FINISHED STEEL

Re-rolling Billets, Blooms, and Slabs.—BASIC: Soft, u.t., £25 4s. 6d.; tested, 0.08 to 0.25 per cent. C (100-ton lots), £25 14s. 6d.; hard (0.42 to 0.60 per cent. C), £27 12s.; silico-manganese, £33 8s.; free-cutting, £28 8s. 6d. SIEMENS MARTIN ACID: Up to 0.25 per cent. C, £31 9s.; case-hardening, £31 17s.; silico-manganese, £34 9s. 6d.

Billets, Blooms, and Slabs for Forging and Stamping.—Basic, soft, up to 0.25 per cent. C, £29 8s.; basic, hard, over 0.41 up to 0.60 per cent. C, £30 8s.; acid, up to 0.25 per cent. C, £31 17s.

Sheet and Tinplate Bars.—£25 3s. 6d.

FINISHED STEEL

Heavy Plates and Sections.—Ship plates (N.-E. Coast), £29 14s.; boiler plates (N.-E. Coast), £31 1s. 6d.; chequer plates (N.-E. Coast), £31 3s.; heavy joists, sections, and bars (angle basis), N.-E. Coast, £27 17s.

Small Bars, Sheets, etc.—Rounds and squares, under 3 in., untested, £31 15s. 6d.; flats, 5 in. wide and under, £31 15s. 6d.; hoop and strip, £32 10s. 6d.; black sheets, 17/20 g., £41 12s. 6d.; galvanized corrugated sheets, 24 g., £52 9s.

Alloy Steel Bars.—1 in. dia. and up: Nickel, £50 18s. 3d.; nickel-chrome, £71 7s. 9d.; nickel-chrome-molybdenum, £79 2s. 6d.

Tinplates.—57s. 1½d. per basis box.

NON-FERROUS METALS

Copper.—Electrolytic, £285; high-grade fire-refined, £284 10s.; fire-refined of not less than 99.7 per cent., £284; ditto, 99.2 per cent., £283 10s.; black hot-rolled wire rods, £294 12s. 6d.

Tin.—Cash, £952 to £953; three months, £935 to £936; settlement, £952.

Zinc.—G.O.B. (foreign) (duty paid), £110; ditto (domestic), £110; "Prime Western," £110; electrolytic, £114; not less than 99.99 per cent., £116.

Lead.—Refined pig-lead: November, £97 10s. to £97 15s.; February, £97 10s. to £97 15s..

Zinc Sheets, etc.—Sheets, 15g. and thicker, all English destinations, £130 15s.; rolled zinc (boiler plates), all English destinations, £128 15s.; zinc oxide (Red Seal), d/d buyers' premises, £136.

Other Metals.—Aluminium, ingots, £166; magnesium, ingots, 2s. 10½d. per lb.; antimony, English, 99 per cent., £225; quicksilver, ex warehouse, £70 10s. to £71; nickel, £454.

Brass.—Solid-drawn tubes, 26½d. per lb.; rods, drawn, 36½d.; sheets to 10 w.g., 31½d.; wire, 32½d.; rolled metal, 29½d.

Copper Tubes, etc.—Solid-drawn tubes, 32½d. per lb.; wire, 317s. 9d. per cwt. basis; 20 s.w.g., 346s. 3d. per cwt.

Gunmetal.—Ingots to BS. 1400—LG2—1 (85/5/5/5), £196 to £218; BS. 1400—LG3—1 (86/7/5/2), £215 to £238; BS. 1400—G1—1 (88/10/2), £335 to £375; Admiralty GM (88/10/2), virgin quality, £340 to £380 per ton, delivered.

Phosphor-bronze Ingots.—P.Bl, £355 to £385; L.P.Bl, £250 to £275 per ton.

Phosphor Bronze.—Strip, 44d. per lb.; sheets to 10 w.g., 46½d.; wire, 49½d.; rods, 44½d.; tubes, 42½d.; chill cast bars: solids 4s. 4d., cored 4s. 5d. (C. CLIFFORD & SON, LIMITED.)

Nickel Silver, etc.—Ingots for raising, 2s. 9d. per lb. (7%) to 3s. 10d. (30%); rolled metal, 3 in. to 9 in. wide × .056, 3s. 3d. (7%) to 4s. 4d. (30%); to 12 in. wide × .056, 3s. 3½d. to 4s. 4½d.; to 25 in. wide × .056, 3s. 5½d. to 4s. 6½d. Spoon and fork metal, unsheared, 3s. to 4s. 1d. Wire, 10g., in coils, 3s. 9½d. (10%) to 4s. 10d. (30%). Special quality turning rod, 10%, 3s. 8½d.; 15%, 4s. 1½d.; 18%, 4s. 6½d. All prices are net.